WEB-BASED CONCEPT INDEXING TOOL FOR ONLINE CONTENT MANAGEMENT OF MEDICAL SCHOOL CURRICULUM - DISSECTING AN ANATOMY COURSE EXPERIENCE

By

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Thesis

Submitted to the Faculty of the

Graduate School of Vanderbilt University

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

in

Biomedical Informatics

August, 2004

Nashville, Tennessee

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To the memory of my grandfather Mounib Rikkabi-Sukkari

and my aunt Fatima Rikkabi-Sukkari.

They influenced my life in so many ways.

ACKNOWLEDGEMENT

My Masters Degree was funded by the Department of Biomedical Informatics. I am very grateful for the opportunities that this department has opened up for me.

This work would not have been possible without the guidance of my thesis committee. My advisor, Dr. Spickard, allowed me to cultivate and pursue my interests. He encouraged me to seek whatever instruments I needed to answer my research questions. I have found nothing but support and encouragement from him throughout this journey. His perspective, that of someone balancing clinical, educational, and informatics responsibilities was invaluable for my work. It is a privilege in Biomedical Informatics to be mentored by Dr. Miller. His vast knowledge of and insight into our discipline, inspired me to seek humility, clarity, and diligence in this endeavor. I thank him for his extensive constructive critique of my work. Dr. Smrekar introduced me to the qualitative research tradition, providing me with spectacles without which I would not have seen most of what I will relate in this thesis.

This work is an extension to brilliant foundational work on KnowledgeMap done by Joshua Denny and Jeffrey Smithers, both working under Dr. Spickard and Dr. Miller's supervision. I will cherish their friendship and memories of long hours discussing topics ranging from Relational Databases to Theology (includes mutual prayers late at night that the server will boot). I want to especially thank Ms. Rischelle Jenkins and Ms. Joyce Green. There is simply not enough space to enumerate all their kind acts towards me.

This pilot study was made possible through the hospitality of Drs. Dalley, Pettepher, Nanney, Lambert, Greathouse, and Halle who welcomed KM into their anatomy course. I want to thank them for their patience with all the technical problems. They sacrificed some of their time so that we can all learn how to make KM better.

I wouldn't have made it this far without the support and love of my parents and Bashar my brother and life-long companion. I would not have been who I am had I not met Rami and Ramzi 17 years ago. We have been asking questions together ever since. Life in a new country would not have been bearable without Ramsey.

Finally I can not understate the happiness and warmth that Anna has brought into my life during the last three years. I will always look back at this time and thank my stars.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

A traditional medical school curriculum consists of a large amount of information presented by a large number of faculty [1]. Medical students learn the basic medical sciences in the early years of their training and apply that knowledge (as well as new knowledge) to patient care problems during their later years' clinical rotations. The expanding role of health care in society mandates that the physician-in-training obtain new skills to be equipped for the 21st century[2, 3]. Thus, new topics such as ethics, research design, public health, and informatics have been added to the core curriculums of many medical schools. These changes make information management for the medical student all the more challenging.

Faced with a growing and evolving flood of information, medical educators require and seek assistance to manage this knowledge base [4-6]. By providing a means to curate medical knowledge and retrieve information quickly and accurately, the field of medical informatics can provide potential solutions to the knowledge management needs of medical students. Although the application of medical informatics to medical education is not new[7], ongoing refinements in the technology and encouraging research findings sustain interest in adapting information technology to support the education efforts in many medical schools[8].

Between the fall of 2001 and summer of 2002, researchers and educators at the Vanderbilt University Department of Biomedical Informatics have constructed KnowledgeMap (KM), a web-based knowledge management tool to support medical instruction at the Vanderbilt University School of Medicine[9, 10]. The KM "knowledge store" contains all curricular documents in a searchable database. The KM interface makes available online this information to students, faculty members, and administrators. (Appendix A) This paper analyzes the use of KM during its pilot implementation in the first year medical school anatomy course in the Fall of 2002.

CHAPTER II

BACKGROUND

Medical Informatics and Medical Education

Medical Informatics is defined as a field of study concerned with the broad range of issues in the management and use of biomedical information, including medical computing and the study of the nature of medical information. [11]

Medical informatics has been used to support the education of health professionals for the past thirty years[7]. Areas in medical education that have been particularly impacted by informatics include (1) teaching medical decision making i.e. “the difficult art of medical diagnosis”[12], and (2) organizing, retrieving, and displaying didactic information. And yet, the modes of delivery and design of computer-aided instruction (CAI) have not remained stagnant, but were shaped by the outcomes of earlier CAI experiments as well as ongoing advances in technology.

The early efforts to apply the computer in medical education date back to the 1950s when data was entered through punch cards. With the advent of interactive keyboard entry, more developments in CAI occurred at several American medical colleges[7]. In 1967, a CAI program was developed at Ohio State University. The Tutorial Evaluation System (TES) was incorporated into the Independent Study Program in the basic medical sciences. The lessons were developed using a computer program that allowed the instructors to enter text under computer guidance without the need for knowledge in programming. Hundreds of interactive hours were entered to the system by the middle of 1970s.[13, 14] This system was an early demonstration of the possibility of delivering curricular content at flexible time i.e. beyond the constraints of the traditional lecture.

Work towards computer simulation of clinical encounters was underway in the 1970s. The Massachusetts General Hospital Laboratory of Computer Science developed simulations of clinical encounters [15, 16]. The highly sophisticated simulations employed a computer language developed for this purpose [17] and well-designed instructional strategy. A somewhat different type of simulation model, termed “CASE” (Computer Associated Simulation of the Clinical

Encounter), was developed at the University of Illinois [18]. These simulations became sufficiently advanced that the American Board of Internal Medicine gave serious consideration to their use in a program for recertification that was to be called “MERIT” (Model for Evaluation and Recertification Through Individual Testing) [19]. Both these systems and TES ran on mainframe computers accessible via a telephone line. The Lister Hill Center of the National Library of Medicine in 1972 (in part responding to a landmark challenge by Stead et al [20]) sponsored a consortium of institutions to share these resources and paid the cost of access via a national computer network[21]. The mainframes at Massachusetts General Hospital, Ohio State University, and the University of Illinois served as hosts. More than 150 institutions participated in the program and students around the country logged thousands of hours.

Over the following decade, expert systems were developed to emulate clinical decision-making. Adaptations of these systems were applied to the service of medical education. The INTERNIST-1 system helped users in performing diagnoses in general internal medicine from 1974 - 1985. Its Knowledge Base required many man-year equivalents of medical expert knowledge to construct. QMR, a successor program, expanded INTERNIST-1 knowledgebase and was later utilized at The University of Pittsburgh School of Medicine to create patient simulation cases [22]. Furthermore, INTERNIST-1 was used as an illustration in a 10-week seminar series called “The Logic of Problem Solving in Medical Diagnosis”. Various diagnostic strategies were taught and employed in a series of case oriented problem solving sessions[23]. Another pioneering medical artificial intelligence system, MYCIN was developed at Stanford University to assist clinicians in using anti-microbial therapy. Later incarnations of the system, GUIDON and NEOMYCIN were reconfigurations of this rule-based system for teaching purposes[24-29]. Similarly, another AI project in medicine – ATTENDING – was designed to ‘critique’ the management of patients. ATTENDING’s didactic value was that it provided suggestions for optimal management of patients based on the actions that physicians have already performed. [30]. However, the mid to late 1980s heralded the “demise of the Greek Oracle model” for medical diagnostic system. Research on Medical Decision support was shifting its emphasis to the physician-user as the “most useful intellect to be brought to bear during the consultative process”[31]. Information technology supports the decision process by providing, among other things, just-in-time access to relevant information[32].

Greenes described in 1989, efforts undergone at the Decision Systems' Group at Harvard Medical School, to provide clinicians with EXPLORER a "desktop knowledge management environment". Knowledge management can be used (among other goals) to "support educational problem solving" and "the pursuit of curiosity". Greenes mentioned the dynamic knowledge display capabilities of hypertext, text that is interconnected through explicit links between content items. [33, 34]. Around that time Dr. Mark Frisse described the potential of hypermedia to improve information retrieval in medicine[35, 36]. He made a case[37] that the then (1990) young hypermedia technology will help people quickly locate and use the "momentarily important" information so essential to their professional activities. Among the examples in medicine that he cited is the collaboration between the NLM and Johns Hopkins School of Medicine that led to the introduction of an on-line version of Victor McKusick's Mendelian Inheritance in Man [The OMIM Database].

In May 1989 the international symposium, Medical Informatics and Education, took place in Victoria B.C.. It was the third conference organized under the "Education" working group of the International Medical Informatics Association, and the first symposium on the subject organized as an open conference on the basis of a general call for papers. The symposium program contained around 150 submitted papers, invited papers and keynotes. The speakers from all over the world addressed pertinent issues in informatics to medical education, drew lessons from its history up to that point, commented on the state of the art of educational technology, and provided insights for future developments.

At the Victoria conference, Levy described factors affecting CAI in medical education through the experience of the MedPLATO project [38]. The PLATO IV system for CAI was developed at the University of Illinois at Urbana-Champaign, the Computer Education Research Laboratory. MedPLATO started in 1973 with intensive efforts to develop a cadre of medical lessons using the PLATO IV system. Limited resources, both in personnel and computing power, prevented the achievement of the original aim of administering the entire basic sciences curriculum. An informal consortium of medical schools, the Health Sciences Network, was established to allow remote access through PLATO terminals to the medical PLATO lessons at UI. Use of the system persisted through the early 80s [39]. Levy cited the "limitations of manually constructed branching" in the instructional design process, i.e. the tedious process of creating different branching scenarios for different user knowledge levels and responses within the "drill and practice" lesson format. It was similarly tedious for clinical as well as basic science faculty to create clinical and basic science "simulations", a teaching format that "strengthens problem-solving skills" and imparts "critical cognitive knowledge in the subject domain". (Refer to Dr. Charles Friedman's 1995 paper on clinical simulation systems [40].) Levy pointed out that MedPLATO was among the first CAI applications to adopt a hypertext system [41] which was abandoned, however, due to limitations on the central memory size.

Non-technical faculty and institutional considerations did impact MedPLATO as well. The promotion of faculty at UI College of Medicine was based near exclusively on research productivity, and computer based lessons were not considered research products in the eyes of the administration. Hence the faculty had little time for or interest in courseware construction even with extensive programming support. They resisted local administrative efforts by the Dean to require faculty to participate in the MedPLATO project. As a result, a small group of non-tenure track basic medical scientists were hired as authors and content experts. The lessons developed, however, were not coordinated with the curriculum as taught to the first year medical students. This was a source of confusion to the students and friction between the two faculty groups, and subsequently led to MedPLATO being regarded as an auxiliary instructional resource and not the primary source of instruction as had been the original aim. In 1993, Bader surveyed policy documents on promotion and tenure from accredited medical colleges in the United States. Of the 126 institutions surveyed, 106 replied. In three quarters of these institutions, development of computer based education material is considered evidence in support of teaching, not the more highly rewarded research or scholarly activity.[42] More recently, in 2001, Slotte published the results of a Finnish nationwide project that surveyed students' and teachers' attitudes towards information technology in medical education. The most notable finding was that teachers used IT more in their research than in teaching[43].

Two CAI [12, 44] systems that were presented as new at the Victoria symposium are PlanAlyzer and Iliad. PlanAlyzer was built on an Apple Macintosh™ HyperCard platform (one of earliest microcomputer-based hypermedia platforms). It combined elements of an expert system with hypermedia to elicit and critique a student's approach to diagnosing common medical disorders (anemia and chest pain)[44]. The evaluation studies of PlanAlyzer will be discussed later. The Iliad system, developed at the University of Utah was a microcomputer-based expert system that mimicked expert diagnosticians. It provided medical students in third year internal medicine clerkships and onward with immediate expert advice, regarding the differential diagnosis and the most appropriate observation to do next, to facilitate learning the problem-solving skills required of physicians[12, 45, 46]. Among the difference between Iliad and INTERNIST-1/QMR was the reliance of its inference engine and knowledgebase on a Bayesian model.

At the Victoria symposium, Marion Ball addressed teaching informatics skills to health care professionals[47]. She described a taxonomy of competencies in informatics. At the lowest levels are "campus wide competencies" required of all students like basic computer skills. The second level comprises "profession-specific competencies" like teaching medical students information retrieval for evidence-based practice of medicine. On the highest level, are "Informatics Specialists/Researcher competencies" like the set of skills needed to construct advanced information retrieval systems. The role of informatics in the education of medical professionals had received wide attention after a landmark report in 1984 by the Panel on the General Professional Education of the Physician (GPEP) of the Association of American Medical Colleges (AAMC) [2]. The report, entitled "Physicians for the Twenty First Century", recommended that "medical schools should lead in the application of information science and computer technology and promote their effective use". In 1995, Koschmann discussed computer literacy in medical education. According to him, exposing medical students to medical information resources could change their orientation to knowledge and learning. Three venues could be utilized: teaching students *about* computers, learning *through* computers (e.g. CAI), or learning *with* computers (i.e. requiring students to use computers in their work on a day-to-day basis). He concluded that none of the approaches is sufficient in itself, however learning *with* computers offers "the most powerful means of fostering the forms of termless learning that students will need to practice medicine in the future" [48]. Surveys done in the late 1980s and early 1990s have consistently shown increasing computer skills and favorable attitudes towards computers among medical students [49-51].

Another major theme in medical education is the often-untapped educational value of patient medical records and the role that information technology can play in that context. In 1969 Dr. Lawrence Weed advocated the use of Problem Oriented Medical Records in his famous article "Medical Records that Guide and Teach" [52, 53]. With respect to training physicians he said: "Since the practice of medicine is a research activity when a clinician deals scientifically with unique combinations of multiple interacting problems, it can be coupled to training in basic science either through the facts themselves or through disciplined approaches to defining problems and handling data." Twenty years later in Victoria, he emphasized information technology as a "knowledge coupling tool"[54] that closes the loop between the clinical realm and the classroom.

Since the advent of microcomputers in 1979-80, computers have become smaller, faster, bigger in storage capacity, and cheaper. The World Wide Web emerged as a marriage of hypermedia and the Internet. It carries promises [55-57] for medical education, and faces hurdles to fulfilling those promises [58]. Such contemporary advances will be discussed within the following sections.

Curricular Content Management

Attempts at cataloguing the medical curriculum have been described as far back as 1962 [4]. Gotlib et al at the University of Ottawa constructed in 1984 a database *within* a pathophysiology course to manage content coverage [59]. Currey et al at Dalhousie University reported in 1984 a database that catalogued basic instruction units across the curriculum. Units were defined as lectures, small group discussions, lab sessions, or clinical experience summary. Searches were possible on words or phrases present in the title or summary fields of these units[60]. Similarly Buckenham et al at University of Toronto designed a database in 1986 that provided curricular planners with accurate information and that helped identify overlap and achieve better integration of topics across the curriculum. For example, they reported that their system helped with the establishment of a separate emergency medicine course because the proponents of that course utilized the database to show the dearth of specific emergency medicine core material in the curriculum. The lecturers entered keywords that described their lectures. In their discussion, the authors questioned the adequacy of keywords in completely reflecting the set of concepts covered in that lecture [61]. Rosen et al described in 1992 the effectiveness of a database to review for omission and redundancy of concept coverage in a Problem-Based Learning curriculum at Rush Medical College. To each of the learning cases, faculty applied keywords from a content vocabulary to record the concepts that were covered in that case. [62] Mann in 1992 described a database at Ohio State University College of

Osteopathic Medicine that was implemented in HyperCard and that allowed Boolean free text word search across the medical curriculum. [63]

The Medical Subject Heading (MeSH) vocabulary that was developed by the National Library of Medicine to provide keywords for cataloging medical articles, was the initial vocabulary of choice for the indexing of the contents of the medical curriculum [64]. Mattern in 1992 reviewed three curriculum management databases at the medical schools of University of North Carolina at Chapel Hill, University of Maryland, and University of Miami. [5, 6]. All databases employed a relational model with the basic units being pre-clinical "instructional unit". All databases included MeSH, or MeSH-derived vocabulary keywords, selected by the faculty members, to annotate the basic units. Only one database (UNC) provided for word search over blocks of free text. Mattern et al pointed to the limitations of MeSH, which was originally designed to cover patient care activity, in adequately representing educational content. A similar opinion concerning the inadequacy of then existing controlled vocabularies was voiced earlier by Piggins et al who reported a computerized method for management of curriculum at Harvard Medical School [65].

Around that time, research was being done along two related axes: (1) automatic mapping of free text to controlled vocabularies (like MeSH), and (2) the National Library of Medicine's Unified Medical Language System (UMLS). The former centers around devising automated means of analyzing free text documents to accurately determine the set of phrases from controlled vocabularies that are present in that document. The UMLS is a set of language tools that include the "Metathesaurus", comprising MeSH and a growing set of controlled vocabularies, and a standardized list of "concepts" intended to represent all concepts in Biomedicine. Eisner described Curriculum Analysis Tools (CAT) a cooperative effort to pool resources of a wide consortium of dental schools. A flexible suite of software that was developed allowed for browsing and analysis of the curriculum. Keywords were selected from UMLS controlled vocabularies [66]. Researchers pointed to the value of using "concepts" instead of "words" as the basic indexing units of free text for purposes of information retrieval [67]. In 1994, Kanter used concept mapping to determine redundancies and deficiencies in the medical curriculum. He distinguished dissimilar clusters of concepts belonging to two educational documents, using the semantic types of co-occurring concepts as basis for the clustering[1]. Improvement in automated algorithms for indexing of free text [68, 69], paved the way for subsequent automated indexing of documents by concepts. In 1993-94, Kanter and Miller developed and applied POSTDOC, an automated system for recognizing concept terms in a free text document. Furthermore, POSTDOC utilized UMLS-based term co-occurrence data to retrieve references from MEDLINE[70]. The “precision” and “recall” metrics for quality of concept recognition were not very acceptable. This was due to many reasons, including inadequate coverage of content by the UMLS Metathesaurus. The Vanderbilt KnowledgeMap team, which included Miller, has reported elsewhere in more detail [10] more contemporary work done in automated concept recognition in educational documents, extending earlier work on POSTDOC.

In 1996 Kanter, the director of the office of medical education at University of Pittsburgh’s School of Medicine, proposed necessary components for a medical-education information system [71]. These components should support learning and instruction as well as administrative and research responsibilities. He conceptualized a three-layered component architecture: a “core” component to store and manage essential data such as student and faculty demographics, an “operational” component to support day-to-day operations such as administration and instruction, and a “strategic” component to guide enterprise level decision making by providing analysis and summary reports.

Zucker described technical challenges for designing a web-based medical curriculum. A complete online curriculum, as distinct from an individual computerized module, must provide dynamic updating of both content and structure and an easy pathway from the professor's notes to the finished online product – providing timely acquisition, conversion, storage, retrieval and presentation of educational documents.[72] A contemporary content management application that fits Kanter’s “operational level” description, is University of Pittsburgh’s “Navigator” System [73]. “Navigator” is a web-based, distributed, personalized application that is used by students and faculty to: 1) create, manage, and access online course resources ; 2) author teaching cases and interactive multimedia presentations, and quizzes; and 3) manage a personal education portal. The developers of the system reported high utilization rates and perceived educational value.

Evaluation of Computer Aided Instruction

Many backgrounds of expertise have contributed to the development and application of medical informatics. In addition to diverse skills and innovations, the experts ushered in different *methodologies of evaluation*.[74-76]. Computer scientists rely on mathematical proofs (among other methods) to demonstrate soundness of their algorithms, but such techniques are rarely applied in Biomedical Informatics. The biostatisticians/clinical investigators use rigorous study designs to measure the effects of medical informatics interventions. Sociologists use such tools as organizational theory [77], and innovation diffusion theory [78] to study how health care organizations assimilate medical informatics into daily activities. [79, 80]. Educators [47] have used ethnographic [81, 82] methods to look at computer usage in class rooms. This diversity is as much as source of advancement as it is of disputes. Friedman and Wyatt's book on Evaluation Methods in Medical Informatics[83] provides motivation for different approaches to evaluation. The book is a reference on a range of evaluation methodologies from subjectivist research design to randomized controlled trials.

In an editorial to the special issue covering the Victoria conference, Möhr et al remarked that over 80% of the contributions were descriptive in nature [84]. They reviewed educational programs and curricula, individual courses, new technologies, or specific systems employed in their course. To them, this was not surprising and "probably even justified" given the "field with a young history and a dynamic evolution – almost to the exclusion of the achievement of any degree of maturity".

Adler and Johnson[1] surveyed the literature in the date range 1966-1998 and found more than 2840 articles that report the application of computer aided instruction (CAI) in medical education [85]. They reported that:

- only less than 5% of the 5143 authors yielded had 3 or more articles published in the CAI literature.
- 60% of citations with abstracts were "demonstrations" of CAI tools that described but did not evaluate CAI applications.
- 11% were "media comparative studies" that compared a CAI application or applications against other teaching media or other CAI applications.
- 13% were analyses of the CAI field.

[1] Kevin Johnson

- Less than 10% of the articles appeared in core medical journals (e.g. JAMA, New England Journal of Medicine).

They concluded that the general medical readership and editors are not aware of the ubiquitous nature of these articles. Based on the fact that demonstration studies are typically results of small-scale projects, they cited limited availability of research funding in CAI in medical education. They also concluded that comparative studies of educational media are difficult to do well, given what Hagler and Knowlton had earlier called, "the implicit threat to internal validity when comparing educational media"[86, 87].

Appendix H includes summaries of selected demonstration, media comparative, and other types of evaluation studies in the literature.

"PlanAlyzer", the CAI program to teach problem solving in diagnosing anemia and coronary artery disease discussed earlier [44], was extensively evaluated for educational outcome[88-90]. The study of PlanAlyzer as an educational intervention extended over three years. During the first year, termed pre-trial study, the controlled experimental design was utilized and included collection of pre- and posttests, computer data, and questionnaires. The pre-trial year served as a formative evaluation since the obtained information was used to determine and eliminate problems in the implementation and adoption of the system as well as addressing emerging experimental design concerns not previously considered. In the two trial years, the investigators very carefully controlled both intervention arms: The same instructional *methods* (self-paced, case based), instructional *content,* and *level* of curriculum material were employed in both PlanAlyzer experimental and non-experimental groups. Identical *effort* was expended in designing the group's courseware. The same *teacher* developed both the experimental group's material. "Novelty Effect" [91] (short term interventions with new media attract disproportionate attention) was deemed unlikely to be present since the intervention occurred over nine weeks. The computer group did not have more instructional support. They found significant gains in "learning efficiency", e.g. time and cost of learning the same content in the experimental group. They did not find differences in "proficiency" i.e. controlled posttest scores[88, 90]. Richard Clark [92] hailed the PlanAlyzer evaluation design as "one of the very few published examples of a thorough and highly professional attempt to avoid the confounding that has plagued similar studies in the past." After a comprehensive review of hundreds of media comparison studies in technology-based instruction [91], Clark had concluded that many of the measured achievement gains attributed to the medium are results of failure to control one or more of the three most common confounders: (1) different instructional methods were used in the different media, (2) different information contents were presented in the compared treatments, and (3) the novelty of newer media tends to increase the persistence and effort that students will invest in the early stages of new programs and that will usually diminish rapidly in approximately 4 weeks. He called for more "economic analysis" of instructional media alternatives.

Dr. Charles Friedman [93] also discussed limitations of the media comparative model: (1) If the testing was administered in paper medium, then this could bias the results against computer based media learners, and vice versa. (2) In a balanced study, the content of CAI should be 'controlled' to match the content of its paper-based parallel. This in turn 'changes' the CAI intervention to suit the desired experimental conditions and compromise the validity of the results. (3) Computer-based applications tend to be in constant flux and evolution (a property of information technology). Freezing the development of a computer application for the purposes of evaluation could strain the evaluation endeavor. (4) Talented and motivated students in a high-stakes environment like the medical school, will find ways to learn regardless of whether they are hindered by ineffective instructional tools or boosted by effective ones. Furthermore, such students may not tolerate being randomized into studies if they believe that their assignment is injurious to their learning. To circumvent the last point, researcher may attempt to remove the studies from 'real environment'. This will remove the motivation to work hard and compromise the generalizability of the results.

As an alternative, he proposed the following research designs: (1) Researchers could compare different *design approaches* to CAI applications. (2) The study of usage patterns in an educational context – e.g. AI methods to analyze log files with performance metrics as outcomes. (3) Assess unique learning outcomes expected from the specific CAI – e.g. assessing the acquisition of spatial knowledge conveyed through sophisticated anatomy packages[94, 95]. (4) Researchs into means of integrating different modes of instruction in the curriculum.

Learning Theory

In recounting their experience with CAI in medicine, some developers pointed to the benefit of positioning CAI research in the context of established knowledge of how learning comes about. In recounting the experience of the MedPLATO project, Dr. Levy wrote "after we have learned these lessons, we were chagrined at our lack of knowledge of others' earlier experiences; we could have saved much time if we had been more experienced in basics of educational theory" [38]

The GPEP report called on medical schools to "identify students who have the ability to learn independently and provide opportunities for their further development of this skill". They should also "consider major reductions in passive learning and require students to be active, independent learners and problem solvers." Levy et al in discussing the results of their study with PlanAlyzer have proposed that "problem based, self-paced, teachware can become powerful vehicles of curriculum reform promoting what the GPEP says is needed"[88]

Many medical schools in the 1980s and 1990s have undertaken reform in their curriculum to embrace "Problem Based Learning" PBL. Extensive studies have been done to determine the efficacy of PBL in medicine. Although the interest in PBL as an instruction method in medicine has dwindled over the last decade, research into its theoretical foundations has identified effective learning strategies. **Appendix I** contains a definition of PBL, a summary of major evaluation studies of its efficacy in medicine as well as published investigations into the learning strategies employed in PBL.

Effective learning strategies that were identified in PBL include elaboration "enhancing the richness of representations in long term memory by thinking about them", critical reasoning, and metacognition. Metacognition, defined as the knowledge about the self as a learner, fosters self-regulation and adaptability of learners. Experts possess skills that control their performance and allow them to adapt to changing situations. For example, experts monitor their problem solving by predicting the difficulty of problems, allocating time appropriately, and noting their errors and checking possible solutions[96]. Metacognition in the context of learning is reflected by the sophistication of, and the self-reflection on learning strategies employed. [96] [97] [98] [99]

Learning theory has attempted to create tools for fostering metacognition. Lin [100] examines two approaches for supporting metacognition: (1) strategy training, and (2) supporting a social environment for metacognition. She stresses the "importance of viewing metacognitive activities not simply as domain skills, nor as ways to build knowledge about the self as a learner, but rather as 'habits of the mind' for developing a balanced cognitively and socially competent learner". Such efforts have been reported in health professional education and they include:

Hmelo and Day, attempted to scaffold learning by asking contextualized questions in the setting of computer simulations of patients[101]. Fonteyn described the use of clinical logs to improve students' metacognition in nursing education[102]. Arseneau described "exit rounds", a reflective activity lead by attendings, after patients are discharged. The premise in this activity is that reflection catalyzes the conversion of 'experience' to 'learning' [103].

Habitual access to a database of medical information may lead to such 'good habits of the mind'. De Bliek et al examined the potential contribution that access to a database of biomedical information may offer in support of problem-solving exercises when personal knowledge is inadequate. Medical students were assessed over four occasions and three domains in the basic sciences. They were asked to use a database, INQUIRER, to respond to questions which they had been unable to address with their personal knowledge for a sample of problems. They found that for a domain in which the database is well-integrated in course activities, useful retrieval of information which augmented personal knowledge increased over three assessment occasions, even continuing to increase several months after course exposure and experience with the database.[104]

CAI in Anatomy

Numerous computer-based educational resources for Anatomy are available. Kim et al reviewed in 2003, 40 *online* anatomy information resources[105]. They proposed criteria to judge the characteristics of the currently available web-based resources. Each site was reviewed and scored based on a survey matrix that included four main categories: 1) site background information, 2) content components, 3) interactivity features, and 4) user interface design components. They found limited use of computer-based design features by the majority of sites. They pointed to the need for comprehensiveness, depth, and logical organization of content. The content should be sufficient for supporting explicitly defined educational objectives, which should target specific end-user populations. The majority of the programs were "image-based and function as atlases". The ability of computers to represent 3D representation of spatial anatomy was exploited by only a few programs. They pointed that the student self-evaluation modules in these programs are largely limited to the identification of structures on 2D images, again missing on the opportunity for more powerful assessment of spatial understanding of anatomy. None of the programs surveyed used underlying formal knowledge representation to represent the symbolic (verbal) knowledge of anatomy. Such representation is necessary for "smarter" manipulations such as inference or querying.

The same authors have earlier described The Digital Anatomist Program at the University of Washington[106-109]. The program aims at the development of an anatomically based software framework for organizing, analyzing, visualizing and utilizing biomedical information. The framework is based on representations for both spatial and symbolic anatomic knowledge, and is being implemented in a distributed architecture. Multiple client programs on the Internet are used to update and access an expanding set of anatomical information resources. This framework serves different practical applications such as symbolic anatomic reasoning, knowledge based image segmentation, anatomy information retrieval, and functional brain mapping.

The National Library of Medicine (NLM) has seen an increasing use of electronic images for clinical medicine and biomedical research. The Visible Human Project was established in 1989 to build a digital image library of volumetric data representing complete, normal adult male and female anatomy. [110] The Visible Human Male data set was released in November 1994, and the Female data set was released in November, 1995. Both publicly available sets consist of MRI, CT, and anatomical images taken from the entire human body.

Faculty and staff at Loyola University Medical Education Network (LUMEN), developed CAI systems tailored specifically to the medical curricula. The website for the anatomy course, designed with specific learning objectives in mind, includes computer lessons, supplements to course materials (e.g., multimedia laboratory dissector, lectures, case study materials), practice examinations; and a web forum for asynchronous interactions between faculty and students. McNulty et al evaluated the website for anatomy class using server usage data, user surveys and examination performance. They found no correlation between satisfaction scores, computer literacy scores and utilization of the system. They observed that usage of the system closely mirrored the content covered in class. When looking at the survey results concerning usage, they were found to “generally substantiate the server statistics”; however “discrepancies were sufficiently large (10% to 20%) to call into question the validity of the surveys”[111]. In another study published in January 2004, usage data from their system was pooled with that of the subsequent academic year for the same gross anatomy course[112]. Again they reported “several discrepancies” despite survey data corresponding “in general” to server statistics. In both papers they cited as an example that as many as 10% of the students who reported using all of the "Comprehension Quizzes" in one year had never even logged to the system. Actual usage statistics corresponding to each of the categories of self-reported usage were not tabulated. As far as performance outcomes, significant differences in CAI utilization correlated with the performances of the students in the course in both studies. Rizzolo et al [113] have recently shown a that students with lower scores on the anatomy final exam used web resources significantly less than students with higher scores.

Various other CAI systems that specifically deal with anatomy have been reported in the literature. A special section in Appendix H summarizes selected papers on CAI in Anatomy.

KnowledgeMap

R.A. Miller and A. Spickard-III and their students at Vanderbilt University department of Biomedical Informatics have constructed a web-based knowledge management tool to support medical instruction at the Vanderbilt Medical School. The stated goal of this tool is to promote online availability of educational resources, and make them available to faculty and students at various levels of their training thus helping to create a longitudinal integration of the medical curriculum. Knowledge Map is available to all VMS students. It consists of the concept identifier and a web application.

The concept identifier is a result of earlier work on the project, in an attempt to "understand" the medical curriculum and be able to perform meaningful searches on it. The KM concept identifier uses lexical tools derived from the SPECIALIST lexicon, heuristic natural language processing techniques, and a rigorous scoring algorithm to differentiate between ambiguous concepts. The researchers compared the performance of the KM concept identifier with the National Library of Medicine's MetaMap (MM) using selected subsets of curriculum documents from which the authors had identified key concepts manually. The results were published in the Journal of American Medical Informatics Association [10]. Of the 4274 gold standard concepts, MM matched 78% and KM 82%. Precision for gold standard concepts was 85% for MM and 88% for KM. KM's heuristics more accurately matched acronyms, concepts underspecified in the document, and ambiguous matches. The most frequent cause of matching failures was concept absence in the UMLS. Thus, KM-CI provides automatic extraction of concepts represented in medical educational texts.

The developers approached various professors asking them to provide us with their educational material. They received good response and started by building the application around 650 documents spanning 18 courses. The documents were from the previous year and so were "free floating" in the system, i.e. not attached to any specific lecture date. They were used as a general backdrop for concept searches.

A web-based application was developed where students would log-on using their institutional log-on id and e-passwords. The site was made secure to address some of the intellectual property concerns raised by the professors. A relational database model was developed to represent the various components that make up a 'medical school curriculum'. This includes such concepts as "lecture" "document" "course" "student" "faculty member" etc... The relational database supported the KM application as it served as a course management application for faculty and course directors. Course directors entered the weekly schedules onto KM, assigning lectures to professors. The individual lecturers would then log-on to the system and upload their documents (handouts + powerpoint presentations). The uploaded documents are converted to HTML and presented in a manner that reflects the course's weekly schedule format so that students and other faculty can browse through them.

Once documents are uploaded, the KM-CI would analyze them for concepts. The concepts obtained from each document would be added to the overall site index. This comprehensive index gives students the opportunity to do searches across the curriculum. In a text box, students enter their search phrase which are mapped to a vector of UMLS concepts and matched with all the documents in the KM repository. A list of matching documents is returned. When one clicks on a document in that list, the search concepts are highlighted.

Please refer to the following paper [9] on the design and implementation of the KM web application, as well as a presentation of other KM features like PubMed searches. Also, Appendix A includes more detailed description and illustrations of the KM project.

CHAPTER III

METHODS

The research questions, and motivation for the quantitative and qualitative research design including the MSLQ questionnaire are discussed in Appendix J.

Setting

Vanderbilt School of Medicine has a four-year medical curriculum. In the first two years clinical exposure is limited and is composed of mostly didactic courses. Courses in the first two years include anatomy, biochemistry, histology, physiology, pathology, neuroscience, microbiology, immunology, physical diagnosis and pharmacology. In the last two years, the students rotate through clinical clerkship modules that cover most clinical specialties. The anatomy course, taught alongside biochemistry in the first semester of the first year, was chosen for a pilot implementation/study in the fall of 2002. Favorable factors for anatomy being the pilot implementation include a relatively small number of faculty members (six) teaching almost all lectures in this course (making it easier to train and support the faculty). Also, most of the lecture and handout material for that course were already in electronic format. When approached, the faculty responded favorably to having their lectures converted to HTML and hosted online. A brief training for the faculty on lecture and document management preceded the semester by one week, and the lectures started being uploaded during the first week of classes. The course was split into three segments each concluded by an exam. The exams took place on the 26th, 68th, and 112th day of the course and there was no overlap in the required material for each exam. IRB approval (#020922) was obtained from Vanderbilt University in January 2003 to conduct this study.

Enrollment

All VMS (4 years) students were invited to use KnowledgeMap. At the time of the study more than 1000 educational documents spanning the four school years were available (over 95% of those were obtained from the 2 preclinical years). The username and passwords were used by the student and faculty to log on to the server and were the same as those needed for other campus applications (mail, registration, etc…). Student subjects were enrolled into our study through two processes: (1) survey instruments were handed out to all students present during the last lab session of the semester on December 12, 2002. The surveys were collected 2 hours later during the hour reserved for anatomy course evaluation. 82 filled surveys were returned to the investigators. The total number of students in the VMS 1 class is 105 (2) Twenty two randomly generated names from the class roster were contacted via email and printed letters, and invited after the course was over to a private interview. Eleven Students agreed to be interviewed. Due to scheduling constraints, 1 student was not interviewed, and 2 students were interviewed together in the same session. All course instructors were contacted requesting an interview. They all agreed and were interviewed in their offices.

Sources of Data

Log Files:

The KM application maintains a Log file which archives and time-stamps most functions performed by users. For this study the log files data between 9/1/2002 and 2/28/2003 (two months after the anatomy course was over) were retrospectively analyzed. For each 1st year medical student, the following usage data was compiled: date of first login, number of log-ins, number of log-offs, the number of times that documents where viewed from a "browsing" screen, the number of times that documents were viewed as a result of a string "search", the number of string searches performed, the number of days in which they logged-on at least once to KM, the number of days in which they logged-on at least once to KM *prior to the survey administration* (on the 112th day). Where possible, the usage data record for each VUNetID was merged with survey results for that same VUNetID.

From the log file, "average days to exam" was compiled. It was calculated as a weighted average of the number of days remaining till the next exam at every log-in. Students may have performed different functions per log-in at different time differences from an exam. For example, 10 days before an exam a student may log-in to view a class presentation of that day. But one day before the exam, that same student may log-in to view many presentations. Therefore the number of days to the next exam across ALL functions was calculated and averaged for each student. In other words, for this metric, each log-in is weighted by the number of documents viewed during that session.

Also, 'Adjusted log-on frequency' was calculated for each student by dividing the total number of log-ons by the number of days that elapsed between the first log-on and the day that the survey was administered.

Survey

A survey instrument was developed to obtain information from students on personal demographics, computer skills, motivation to learn, satisfaction, and open ended comments about met and unmet expectations of KM.

The survey was administered on the 16th week of the study (112th day) at the conclusion of the course during the last lab session and subsequent class meeting to complete course evaluations. The cover page of the survey included IRB consent form for the study, brief study-related information, and a field where students optionally entered their VUNetID (user ID) and indicated whether they wished to view their MSLQ (see below) scores.

The survey is located in Appendix B. The first section included questions relevant to the overall experience and satisfaction with KM, opinions about specific features of KM, and personal patterns of use of the system. The second section of the survey assessed student's access to computers and personal computer skill level. A previously validated scale was used to rate student's computer skills from least to most proficient [114]. The third section of the survey consists of thirty-one 7-point Likert scale questions. These were adopted from the Motivated Strategies for Learning Questionnaire (MSLQ) [115, 116]. The MSLQ, a widely cited and readily available instrument, combines both motivational and learning strategies scales. The questions were taken from five of the constructs that make up the MSLQ: Extrinsic Motivation, Intrinsic Motivation, Test Anxiety, Elaboration, and Metacognitive Self-Regulation. See appendix C for a description of these constructs. The questions adopted from MSLQ were shuffled and presented in random order. For each instance of the survey, a score that ranges from 1 - 7 was calculated for each of the five constructs, with higher score values denoting more concordance with the constructs. The fourth and fifth sections of the survey included demographic information and sections for students to provide comments about their experience with KM.

Student Interviews

An interview protocol, found in appendix D, was developed that mapped to the conceptual framework of the study. The protocol consisted of a set of questions covering the following major themes: Computer Skills and Attitudes, KM and Study Habits, Information Needs, Viewing Lectures across an "Integrated Curriculum", and Satisfaction and Usability.

Survey or usage data for individual students were not known to the interviewer at the time of the interview. All interviews were audio taped. The previous interview tapes and notes were reviewed prior to proceeding to the next interview. Over the course of the 9 interview sessions, adherence to the protocol was maintained, however, some topics provided more insight into the study objectives than was determined a priori. Hence the primary investigator allocated more relative time to visit and for students to elaborate on certain topics over the course of the interviews.

The interviews were transcribed and transcripts were entered into a QSR Nud*ist 6 database. Based on the content of the transcripts, a hierarchy of "nodes" - topics – was created. The transcripts were encoded. Examples of node include: "KM satisfaction", "Study habits", "information retrieval, subset: Specific methods", and "Information Retrieval, subset: Prospective searches in curriculum". "Encoding" refers to the process of highlighting text passages[2] within the transcripts and mapping them to a specific topic node. A certain passage could be mapped to more than one node. During the course of encoding, a need for addition of new nodes was determined. Documents that were encoded prior to addition of new nodes were revisited and coded, where necessary, using the "newer" nodes. Finally, node reports were generated. A node report includes the node title and description and all text passages – across all transcripts – that were coded under that node. Summaries of node reports were prepared and utilized as basis for study results below.

Faculty interviews

All teaching faculty members of the anatomy course agreed to be interviewed. Only one interview was not taped due to technical difficulties. The interview protocol is located in

[2] A passage is a contiguous substring of a transcript document. Passage encoding could be done on staggered substrings.

appendix E. The topics covered were: Computer Skills and Attitudes, Information Needs, Thoughts on “Integrated Curriculum”, and Perceived Effects of KM on Instruction. The reporting and analysis of results was done in a similar fashion to student interviews.

CHAPTER IV

RESULTS – LOG FILES AND SURVEYS

General Overview:

From 9/1/2002 and 2/28/2003, 104 out of 105 first year medical students logged on to KM. Three categories of students were defined, those who filled the survey and provided identification, those who filled the survey anonymously and those who used KM but did not fill the survey (Table 1).

Table 1 – VMS1 Student Participation in the Study

Category	Description	#
	Logged on to KM* / Total VMS I students	104 / 105
A	Filled survey – provided username	73
B	Filled survey – did not provide username	8
C	Did not fill survey – logged on KM	32

* At least once between 09/01/02 & 02/28/03

Fifty six percent of the responders to the survey were males. There was no significant difference in gender proportion between students in category A and students in category B (p=0.727 Fisher's exact test). Nor between the survey composition and that of the class (62/105 in VMS1; p=0.9)

Usage:

Most students logged on to the system for the first time during the first 26 days of the study, i.e. before the first exam (Table 2).

Table 2 – Date of first log-on

First Log-on occurred	**#**
Prior to first exam (9/1/02 - 9/26/02)	74
Prior to second exam (9/27/02 - 11/7/02)	25
Prior to third/Final exam (11/8/02 - 12/20/02)	3
After course was over (12/21/02 – 2/28/03)	2
After study was over (March'03)[3]	1
Total:	105

Self reported frequency of use is shown in [Fig 1]. 5 (6.2%) Students reported never using KM, 18 (22.2%) reported logging on less than once every 2 weeks, 16 (19.8%) less than once a week, 30 (37%) 1-5 times per week, and 12 (14.8%) more than 5 days a week.

The average number of log-on days *prior to the survey administration* was 15.1 days out of 112 days. (95% CI: 12.8 – 17.4; min = 0; max = 56) [Fig 2]. There was no significant difference in 'prior days' between the survey responders and the non-responders. (15.0 vs 15.2; p=0.95). The average the number of unique days that students logged on was 18.2 days out of 175 total study days (95% CI: 15.6 – 20.8; min = 0; max = 62) [Fig 3]. There was no significant difference in 'log-on days' between the survey responders and the non-responders (18.3 vs 18.1; p = 0.93).

[3] In March 2003, KM administrative data showed 105 active users from VMS1

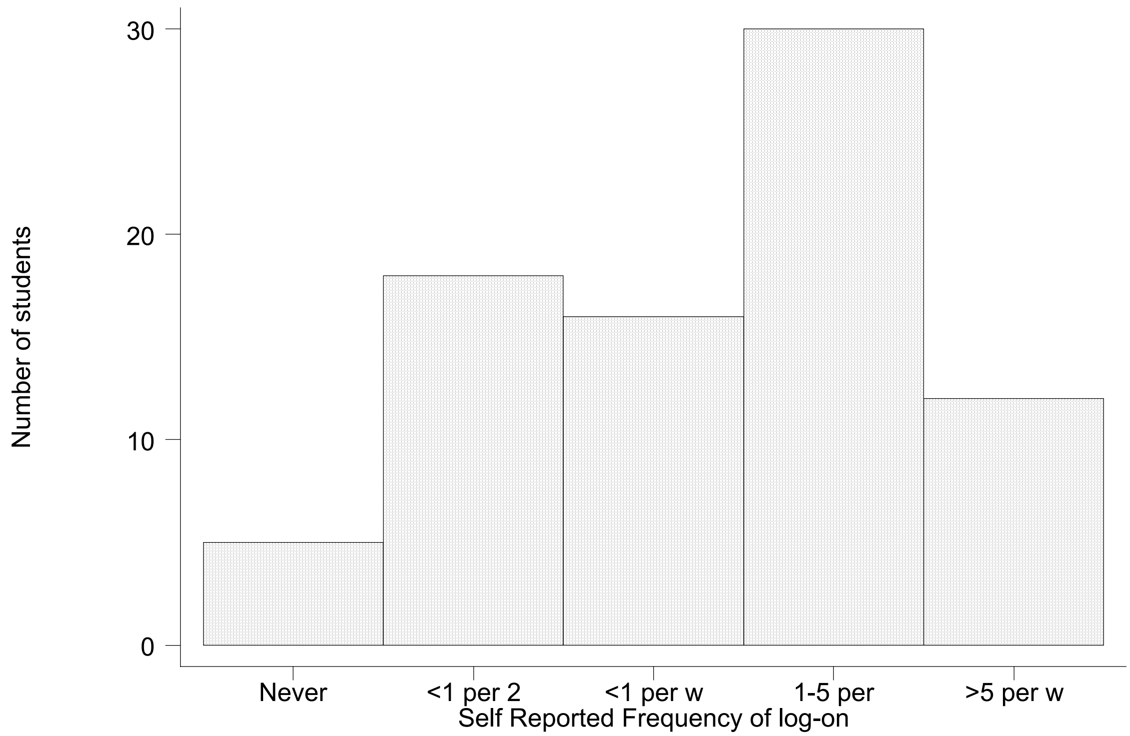

Fig 1 – Self Reported Frequency of Log-on

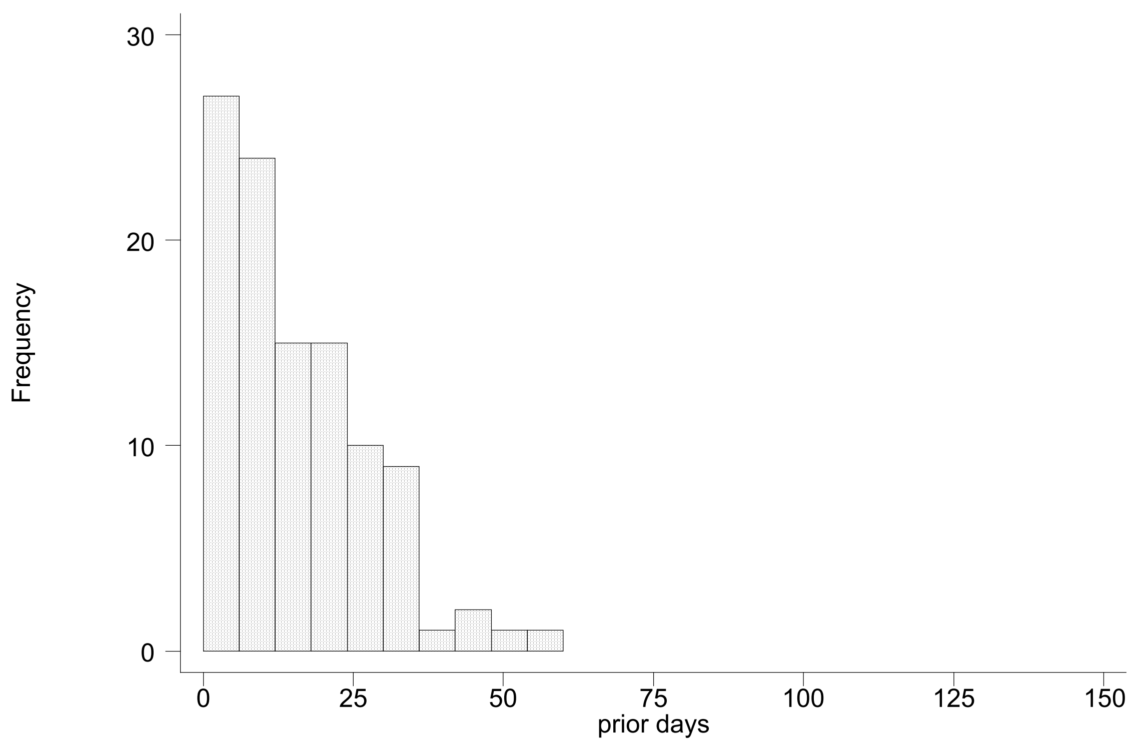

Figure 2 –Number of Log-on Days Prior to the Questionnaire Administration

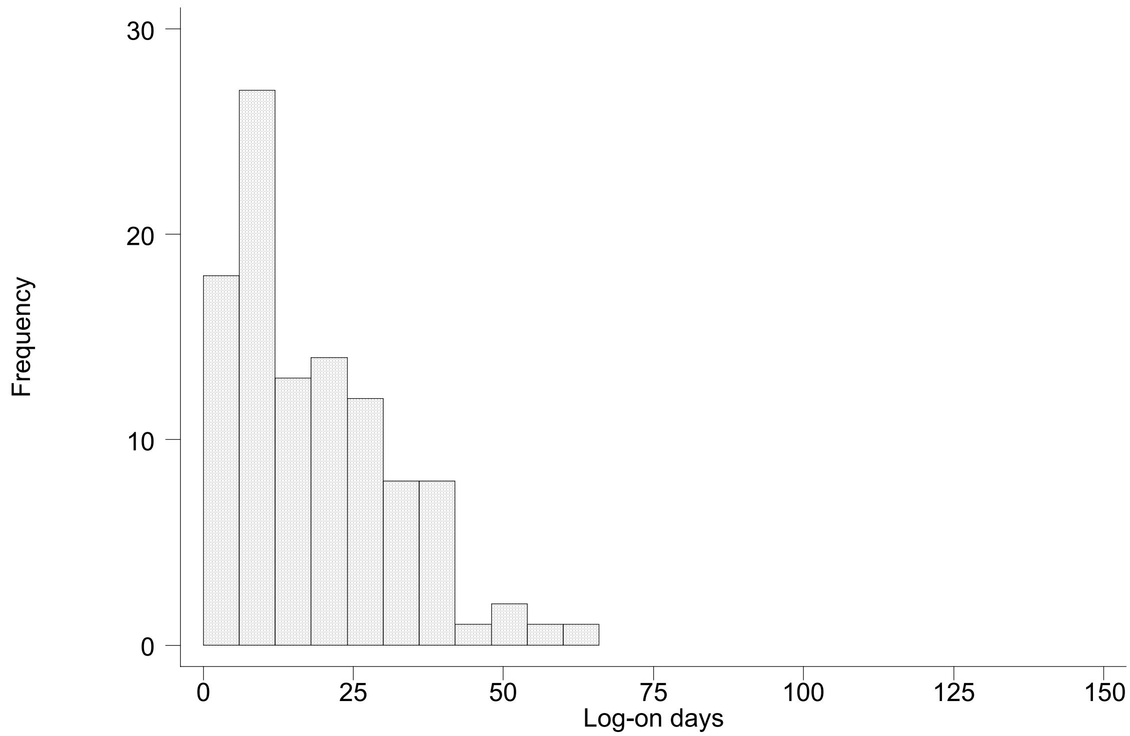

Figure 3 – Number of Log-on Days Throughout the Whole Study

The concordance per student between actual use, as calculated from the log file, and the self-reported frequency of use was calculated. The average number of log-on days prior to survey administration for each of the self reported categories were: 0.75 (“Never”), 7.8 (“<Once per 2 weeks”), 12.9 (“<Once per week”), 22.8 (“1-5 times per week”), and 35.5(“>5 times per week”). The Kruskal-Wallis test (instead of ANOVA because of unequal variances) indicated significant difference in the mean across the 5 categories ($p=0.0001$). Pair-wise analysis of means (Mann-Whitney method) found significant difference in log-on days between all pairs of responses ($p<0.01$) except for (“<Once per 2 weeks) and (“<Once per week”). For further analyses these two response categories were collapsed into a new category (“<Once per week”) with 10.2 average log-on days.

Next the log file data for ‘prior days’ was converted into discrete values by choosing two cut-off points such that the highest is five times the lowest. Students with ‘priordays’ lower the than lower cut-off, in between both points, and larger than the higher cut-off were assigned values 2, 3, or 4 respectively on the discrete value scale. Students with ‘priordays’ of zero were assigned the value 1. This mapping is intended to mirror the {“never”, “<Once per week”, “1-5 time per week”, “>5 times per week”} scale. The survey was administered on the 16th week so the cutoffs was chosen as “16” and “80”. This resulted in 64.4% agreement between the reported and the true daily usage. The Kappa statistic for this comparison was 0.421. Generally, a cut-off of 0.4 is for “good” concordance and 0.75 is for “excellent” concordance. Table 3 shows the agreement percent as well as the Kappa-Statistic for various cut-off values. The highest concordance was observed for the cut-off values <9,45> [Table 4].

Table 3: Kappa Statistic for Concordance at Different Cut-offs Values of ‘Prior Days’

Cut-off values <x,5x>	Agreement (%)	Kappa
<16,80>	64.4	0.421
<14,70>	61.4	0.378
<12,60>	64.4	0.424
<10,50>	64.4	0.431
<9,45>	65.8	0.453
<8,40>	64.4	0.438

Table 4: Concordance Table for Cut-off Level <9,45>

Self-reported Frequency	‘prior days’ for cut-off <9,45>				
	0	1 - 9	9 - 45	> 45	
Never	3	1	0	0	4
<1 per wk	0	21	9	0	30
1-5 per wk	0	4	23	1	28
>5 per wk	0	0	10	1	11
Total	3	26	42	2	73

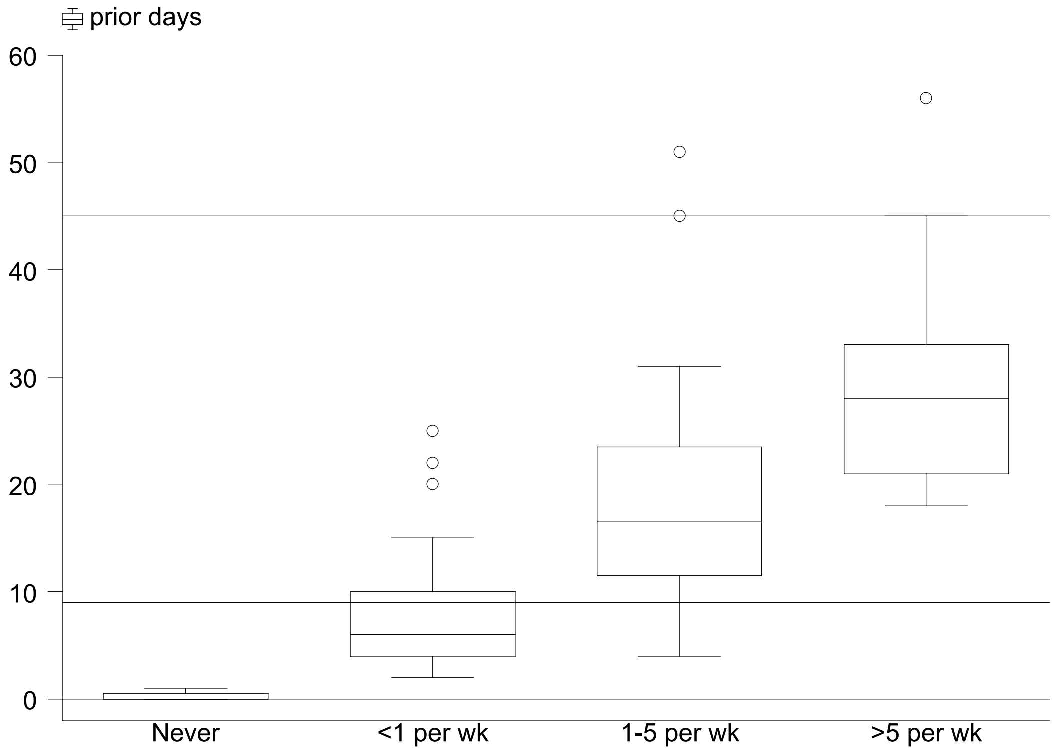

Figure 4 – Mean and Spread of ‘Prior Log-on Days’ for Each Group of Self-Reported Frequency of Use

Fig 4 shows the cut-off lines and the mean and spread of the number of days logged on to the system prior to the survey administration, for each group of self-reported frequency. The upper cut-off line needs to be moved down to the 20s to successfully segregate between the “1-5 per wk” and the “>5 per week” groups. In this case, however, the first cut-off line (which by definition needs to be one-fifth of the value) will be pushed down to around 5, erroneously lumping the “<1 per wk” group with the “1-5 per wk” group. This graph shows that it is more likely that high frequently users cannot accurately recall their usage frequency.

Global Patterns of Use

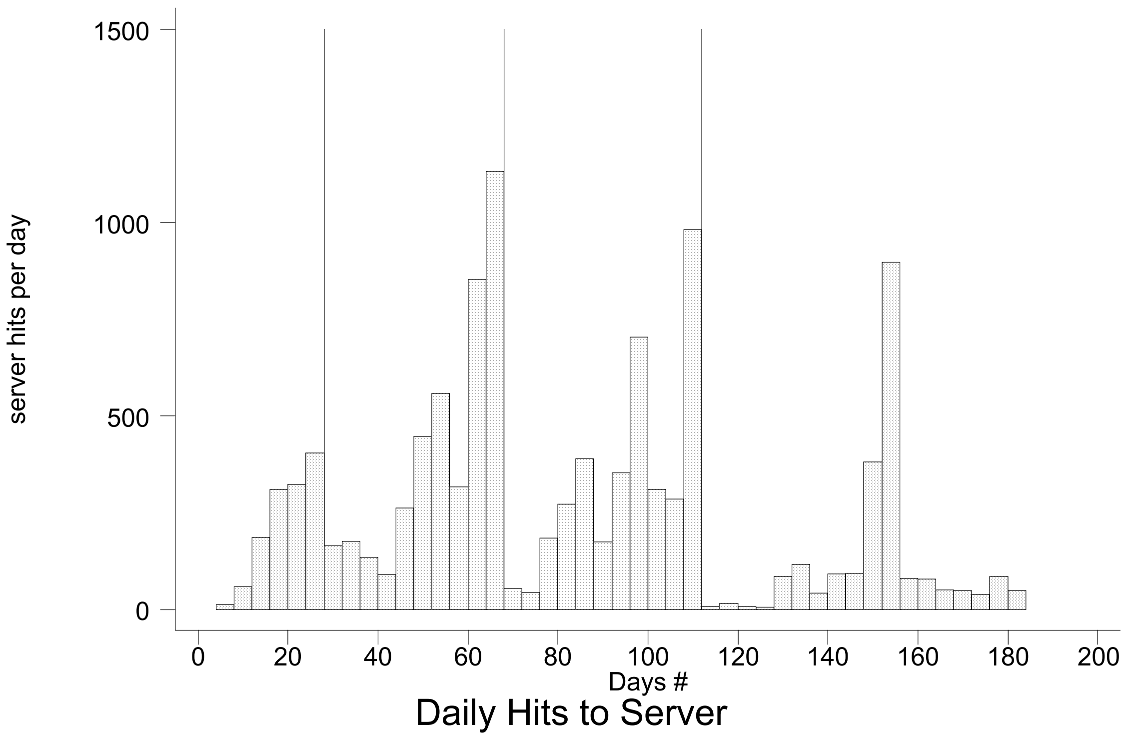

Figure 5 – Daily Hits to Server

Figure 5 shows the number of timestamps in the log file generated by first year medical students, per day. Each column represents 4 days, and the 3 vertical lines represent the three written exams of the anatomy course. The utilization of the system reached its peak in the last few days before an exam. Bars on the right of the 3rd exam represent usage after the anatomy course was finished. The 4th peak coincides with the first exam in the Spring Semester Histology exam.

This pattern was repeated throughout the course. The number of days preceding the first exam was 26 days, that preceding the 2nd and 3rd was 42 and 43 days respectively. Note that the server experienced multiple episodes of downtime (lasting a few minutes) on the night directly preceding the 2nd exam. This may have caused the recorded number of hits to the server in the log file to be less than the number of actual requests. Server hits as they relate to exams are shown in Table 5.

Table 5 – Number of Log File Timestamps Caused by VMS1 Students at Different Intervals of the Study

Log File Entries due to VMS 1 students	**#**
Prior to first exam (9/26/02) – 26 days	1264
Prior to second exam (11/7/02) – 42 days	4193
Prior to third/Final exam (12/20/02) – 43 days	3730
After course was over, through end of study (2/28/03)	2175
Total:	11362

Table 6 contains summary information of different usage metrics. Students logged-on to the system an average of 32.7 times during the semester (Fig 6). The number of log-ons is roughly linearly correlated with the number of *unique days* in which they logged-on (R-squared = 0.91 / slope=1.99 / Fig 7). The average number of documents viewed by each student through the 'browse' and 'search' functions was 59.8 and 4.1 respectively. There was a slight linear correlation between the number of documents viewed through 'browse' and the number of log-ins. (R-squared = 0.85 / slope = 1.82 / Fig 8). However there was no such relationship between the number of log-ins and the number of documents viewed through 'search' function. (R-squared = 0.048 / Fig 9).

The distribution of the "average number of days till next exam" for each student is shown in Fig 10. {Mean = 12.6 days; 95% CI: 11.6 – 13.6}. A uniform log-in rate throughout the semester would have produced a value 19.8 ($p<0.0001$). The distribution of "*Weighted* average number of days till next exam" is shown in Fig 11. {Mean 12.3; 95% CI: 11.2 – 13.3} The two means differ by 0.3 days ($p=0.02$).

Table 6 – Usage Metrics Calculated from Log File

Usage metric	Mean	95% CI
Number of days users logged on to the system throughout the study ('log on days')	18.2	15.6 – 20.8
Number of days users logged on to the system during the anatomy course ('prior days')	15.1	12.8 – 17.4
Total number of Log-ins to the system	32.7	27.3 – 38.1
Number of documents viewed through "browse" function	59.8	49.0 – 70.2
Number of documents viewed through "search" function	3.0	1.8 – 4.2
Number of string searches performed	4.0	2.7 – 5.4
Average Number of days till next exam	12.6	11.6 – 13.6
Weighted average number of days till next exam	12.3	11.2 – 13.3

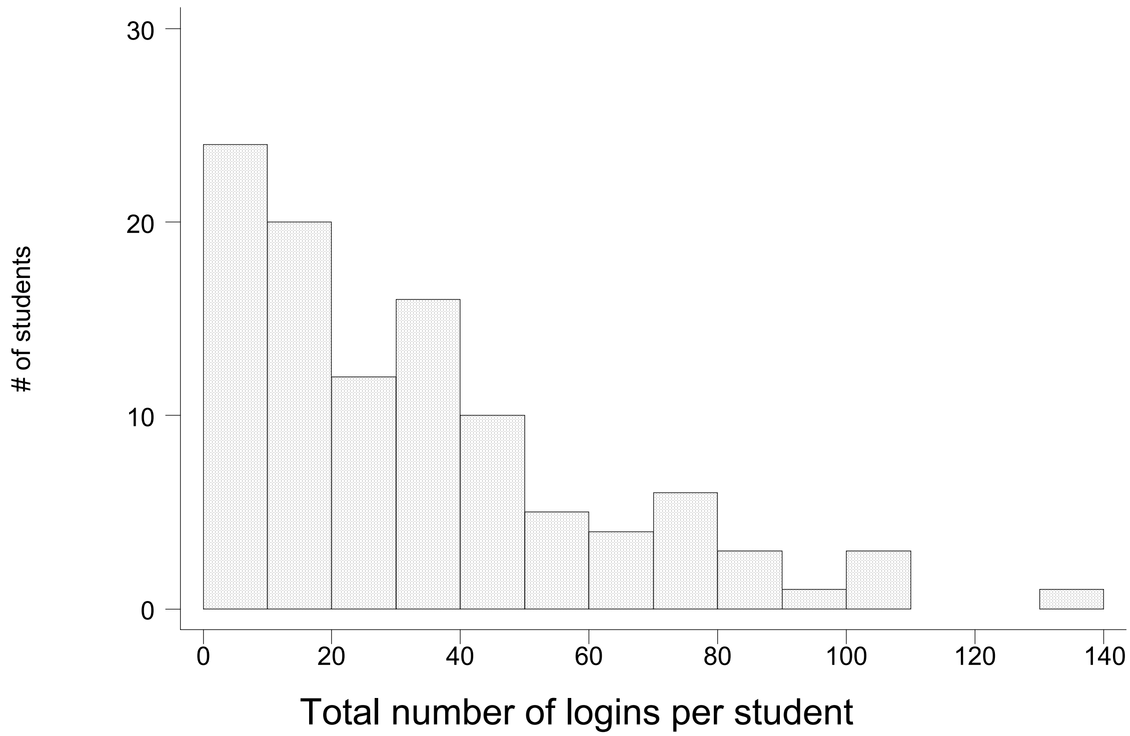

Figure 6 – Histogram of Number of Log-ins per Student

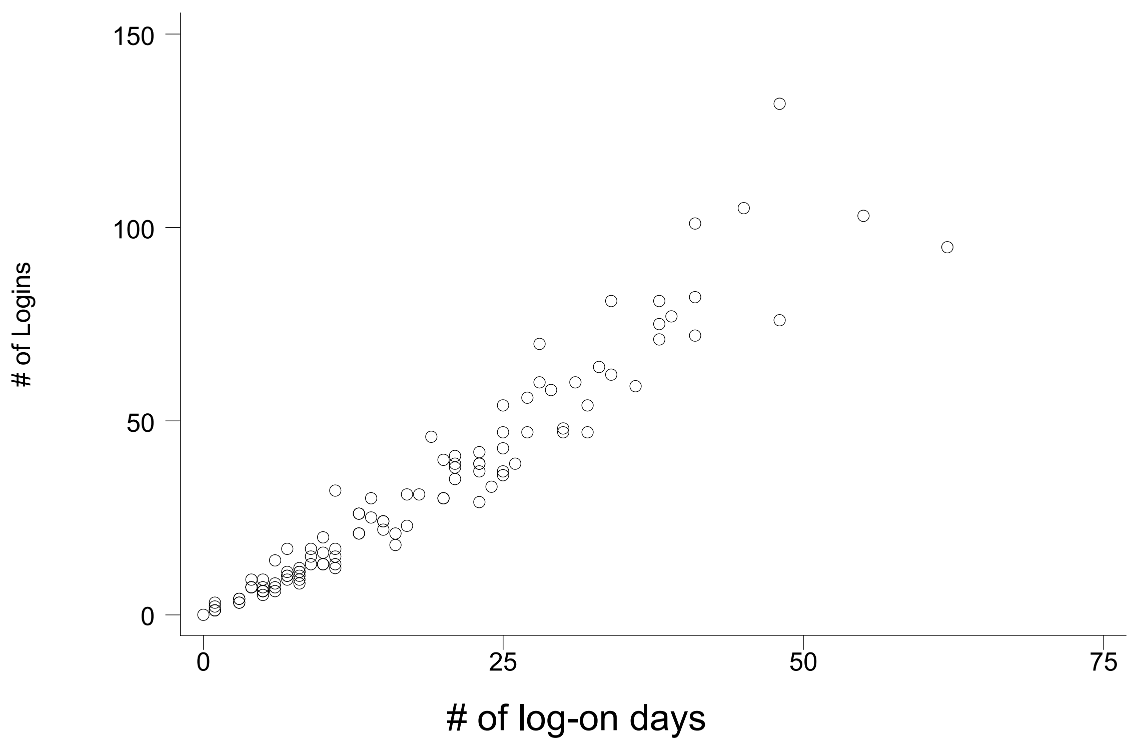

Figure 7 – Number of Log-ins vs. Number of Log-on Days for Each Student

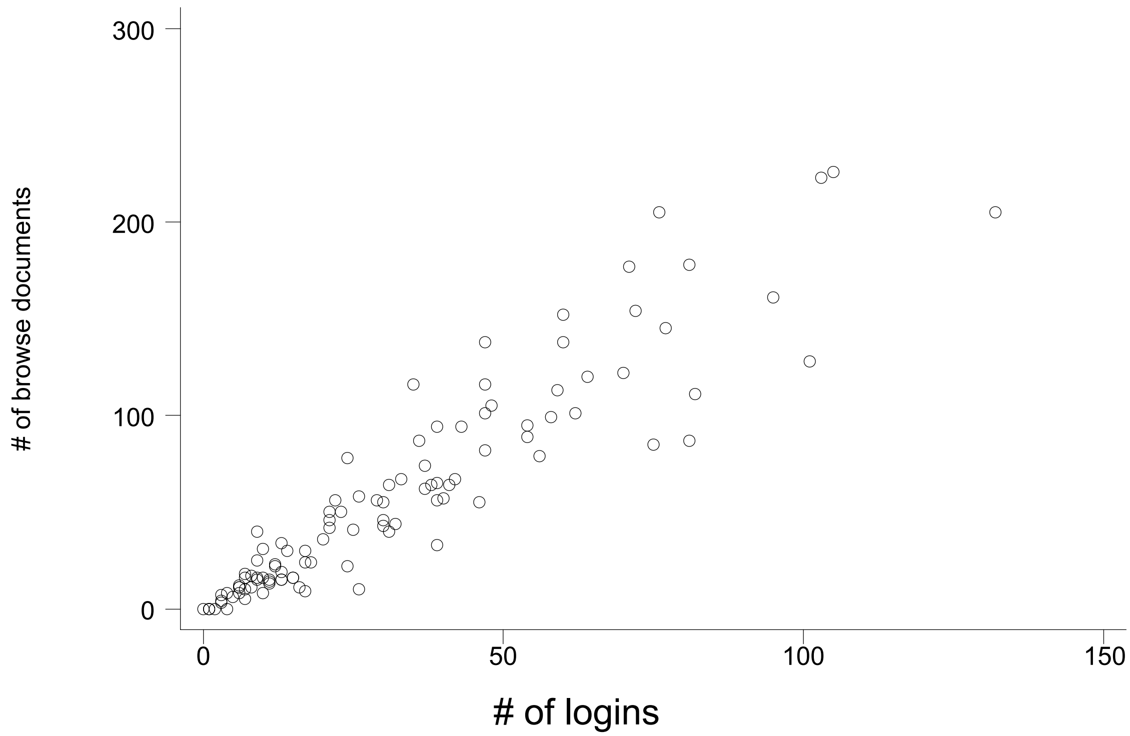

Figure 8 – Number of Documents 'Browsed' vs. Number of Log-ins for Each Student

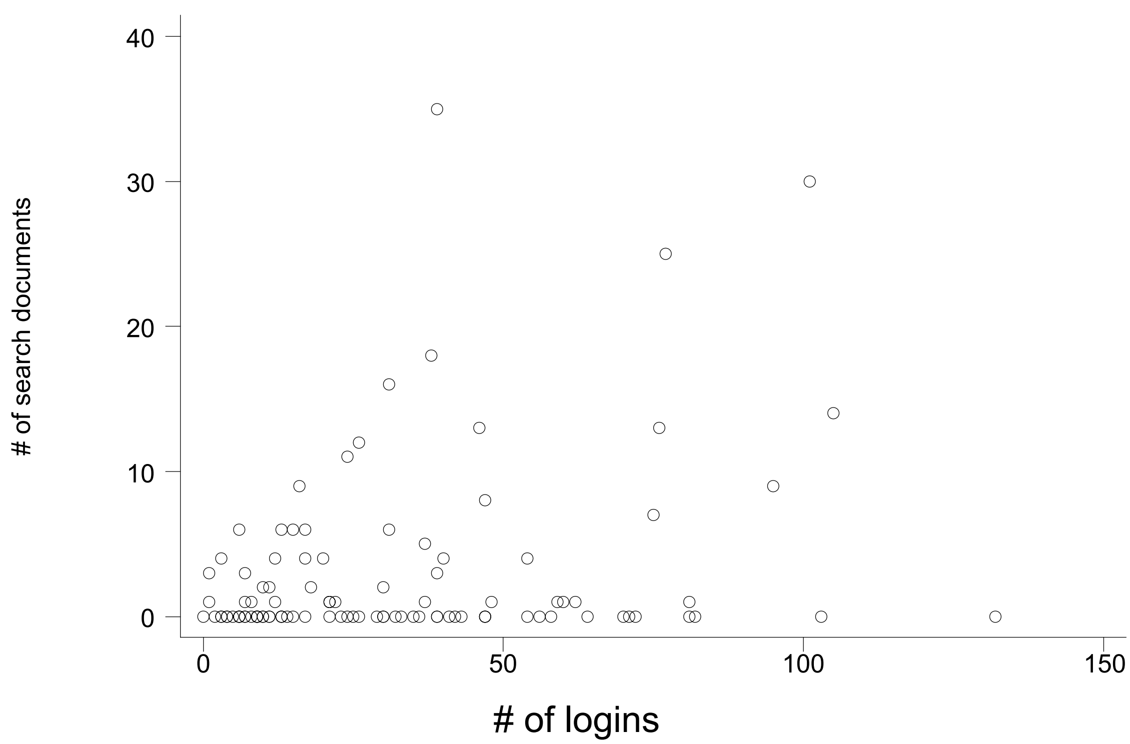

Figure 9 – Number of Documents Retrieved Through 'Searching' vs. Number of Log-ins for Each Student

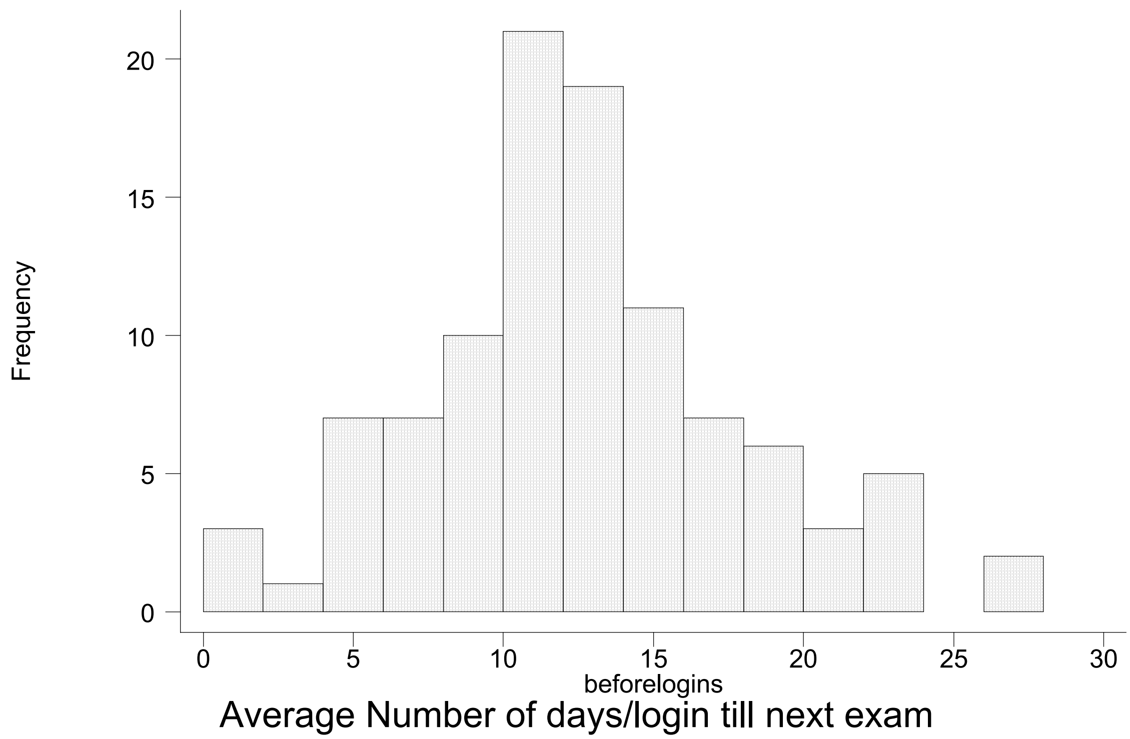

Figure 10 – Distribution of the "Average Number of Days Till Next Exam"

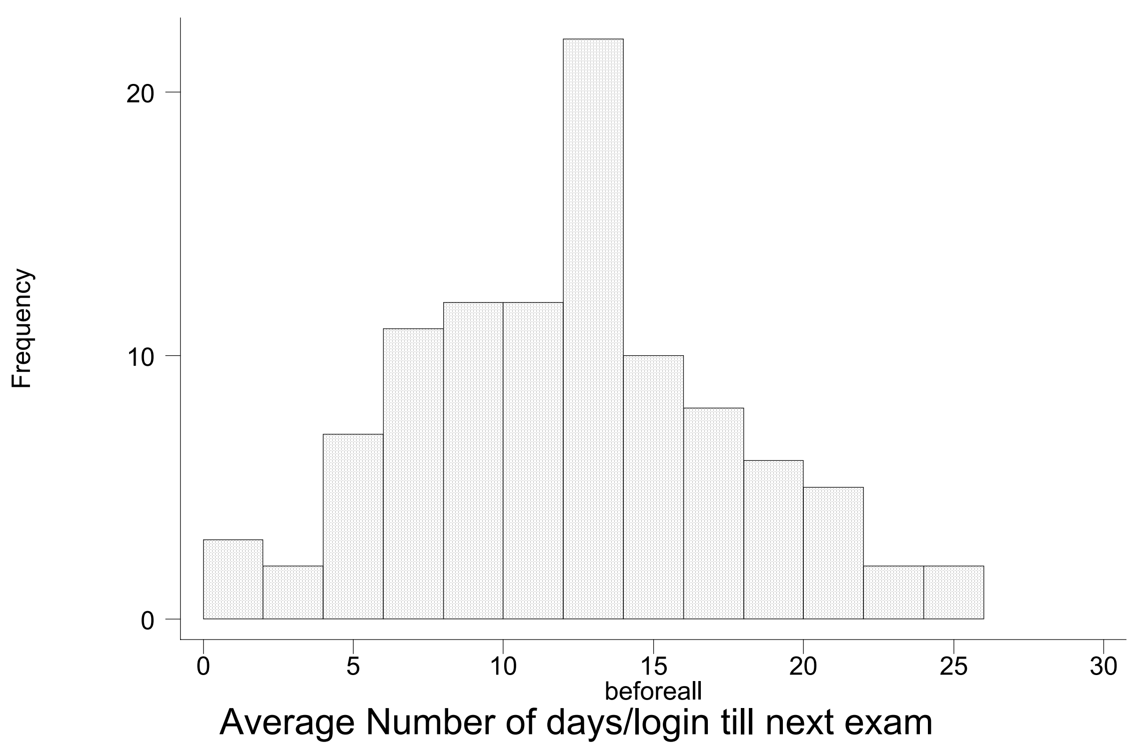

Figure 11 – Distribution of the "*Weighted* Average Number of Days Till Next Exam"

Computer Skills Questionnaire

7 out of 81 students (category A & B) reported that they *don't* own a computer at home. When asked on how they perceive the effects of computers on their education, 66 students answered "very beneficial", 13 answered "somewhat beneficial" and 2 answered "Neither detrimental nor beneficial". No one reported that computers are detrimental to their education.

Scores on the computer skills questionnaire ranged from 1.0 (least proficiency) to 3.0 (most proficiency). The mean score was 2.35 (95% CI: 2.26-2.45), a similar score was found using the same rating scale on senior Vanderbilt medical students the year before the study. [114]

Table 7 shows usage information by level of computer skills. Students were assigned to three categories of computer skills: low, moderate and advanced corresponding to survey score intervals [1-1.66], [1.66-2.33] and [2.33-3.0] respectively.

Table 7 – Usage Statistics for Different Computer Proficiency Groups

Usage Metric	Low N=6	Medium N=27	Advanced N=40	p-value ANOVA
First log-on (day of occurrence)	45	36.8	24.7	0.15[1]
Number of *days* in which they logged on to the system *prior to the survey*	9.2	14.8	16.1	0.44
Total number of log-ons	23.7	34.4	33.4	0.72
Number of documents through 'browse'	41.5	65.2	62.5	0.68
Number of documents through 'search'	3.3	2.6	3.9[2]	0.70

[1] Failed Bartlett's test for equal variances, so Krusskal-Wallis method was used
[2] Would have been 6.9 if we include a first year student working on a research project related to KM that required him to perform a very high number of searches (121 searches).

Comparing students who own a computer at home and those who don't, there was no difference in the number of log-ons to the system, or log-on days. However the day of first log-on to the system was higher in those who did not own a computer (55.8 vs 28.0, p=0.02). When stratified by computer proficiency, however, there were no differences in day of first log-on between the two groups. (p=0.26,0.07,0.52 for low, medium, and high computer proficiency respectively). We note the small number of students who do not own a computer (n=7) with respect to such an analysis on confounding effects.

Satisfaction:

Table R.8 Shows student responses to the question about their general satisfaction with KM. The table includes all students who filled the questionnaire (Category A & B)

Table 8 – Overall Student Satisfaction

Satisfaction Level	Freq	%
1 – Very dissatisfied	1	1.3
2 – Somewhat dissatisfied	2	2.5
3 – Neither satisfied nor dissatisfied	13	16
4 – Somewhat satisfied	45	56
5 – Very satisfied	19	24

In Table R.9, satisfaction level 1 - 2, and level 4 – 5 were collapsed, and the three resulting satisfaction levels were compared with usage data from the log files.

Table 9 – Usage Statistics for Different Satisfaction Groups

Usage Metric	Dissatisfied N=2	Neutral N=11	Satisfied N=59
Number of *days* in which students logged on to the system *prior to the survey*	20.5	2.9*	17.4*
Total number of log-ins	41	5.9*	38.3*
Number of documents viewed through 'browse'	79.5	11.4*	71.6*
Number of documents viewed through 'search'	0	0.73+	6.0+
Weighted average number of days till next exam	13.0	13.7+	10.9+

*Pair is Significantly different (P<0.005 in all cases) – ANOVA, bonferroni correction
+Pair is not significantly different

Table 10 Shows a trend in relationship between having a computer at home and satisfaction with KM. No significant difference is observed in computer home ownership between the three different satisfaction levels. The proportion of computer ownership may differ between neutral students and satisfied students. (77% vs. 93% respectively, p=0.05). However, similar to usage data, this proportion does not differ when both groups are stratified by computer proficiency. (0.63,0.34,0.88 for low, medium and high proficiency respectively)

Table 10 – Computer Ownership Within Each Satisfaction Group

Owns Computer	Satisfaction Level			
	Dissatisfied	Neutral	Satisfied	
No	1	3	4	8
Yes	2	10	60	72
	3	13	64	80

Chi-squared test, no difference in proportions (p=0.071)
Similarly for Fisher's Exact test (p=0.065)

Table 11 The majority of students did not experience substantial technical errors.

Table 11 – Reported Frequency of Technical Errors

Reported frequency of error	#	%
0-20% of the times I used KM	56	70.9
20-40% of the times I used KM	16	20.3
40-60% of the times I used KM	6	7.6
60-80% of the times I used KM	0	0.0
Almost every time I used KM (80-100%)	1*	1.3

* This person had logged on to the system 22 times and has reported to be "somewhat satisfied with KM."

Table 12 Shows student ratings of various technical aspects of KM using a 7-point Likert scale (1 "not at all true of me," 7 "very true of me"). The small number of students in the dissatisfied bin prevented us from drawing statistical conclusions with respect to that category.

Table 12 – Likert Score Agreement with Questions on Technical Aspects of KM for Each Satisfaction Group.
1 - Not at all true of me; 4 – Neutral; 7 – Very true of me

Question	Mean (All)	Dissatisfied N=3	Neutral N=13	Satisfied N=64
Download speed is an important factor for my satisfaction with the system	6.2	6.7	6.2	6.2
It is important to me that KM supports browsers other than Internet Explorer.	3.4	3.0	2.8	3.6
I would like to have the ability to download the lectures in their original file format – as opposed to HTML	5.2	4.7	5.1	5.2
I am frustrated by the technical errors	4.1	5.5	3.0	4.3
Technical errors made me use KM less frequently	2.9	4.0	2.0^{+}	3.0^{+}

Table 12 – Likert Score Agreement with Questions on Technical Aspects of KM for Each Satisfaction Group.

1 - Not at all true of me; 4 – Neutral; 7 – Very true of me

Technical errors prevented me from accessing important information when I needed it.	3.6	3.7	2.1^{+}	3.8^{+}
I feel that there was a long time lag between the lecture presentations and the time they were made available online	3.9	4.5	3.7	3.9
Browsing documents and the class schedule was convenient and easy	5.6	4.3	4.1*	5.8*
Using KM to **search documents** by keywords was convenient and easy	5.0	3.0	3.9	5.2

*Significantly different +Not significantly different

In table 12, significant differences in usage were found among the satisfaction groups, so the same questions above were broken down by usage. Table 13 shows the same results as R.12 with the columns representing self reported usage frequency instead of satisfaction level. With increased usage, there is an increasing trend in agreement with statements that refer to encountered technical errors. The more students used the system the more agreement they had with negative statements concerning occurrence of technical errors (Shaded rows).

Table 13 – Likert Score Agreement with Questions on Technical Aspects of KM for Each Self-Reported Usage Group

	Self-Reported Usage			
Question	Never N=5	<1 per wk N=18	1-5 per wk N=46	>5 per wk N=12
Download speed is an important factor for my satisfaction with the system	6.7	6.1	6.2	6.6
It is important to me that KM supports browsers other than Internet Explorer.	3.3	3.4	3.4	3.8
I would like to have the ability to download the lectures in their original file format – as opposed to HTML	5.3	5.0	5.2	5.4
I am frustrated by the technical errors	2.5	3.3*	4.9*	4.7
Technical errors made me use KM less frequently	1.0	2.8	3.0	3.0
Technical errors prevented me from accessing important information when I needed it.	1.0	2.8*	4.0	5.2*

Table 13 – Likert Score Agreement with Questions on Technical Aspects of KM for Each Self-Reported Usage Group

I feel that there was a long time lag between the lecture presentations and the time they were made available online	1.0	3.4	4.3	4.3
Browsing documents and the class schedule was convenient and easy	1.0	5.4	5.6	6.3
Using KM to **search documents** by keywords was convenient and easy	1.0	5.0	5.1	5.1

* p = 0.09 & p = 0.03 respectively

Students who reported higher frequency of use, were more frustrated with technical errors and felt that technical errors prevented them from accessing information when they needed to. However, they did not agree with the statement that it led them to less usage of KM. This finding is compatible with the hypothesis that technical errors, although frustrating, did not lead to a lower adoption rate.

MSLQ Questionnaire

Eighty students filled out the MSLQ section of the survey. Their scores were calculated for the 5 scales: metacognitive self-regulation, elaboration, test anxiety, intrinsic motivation, and extrinsic motivation. Table 14 shows means for the entire class on the 7-point scale. The p-values refer to the null hypothesis that the answers were due to random filling of MSLQ questionnaire (mean=4).

Table 14 – MSLQ Scale Scores

Scale	Mean	p-value
Intrinsic Motivation	5.37	<0.0001
Extrinsic Motivation	4.29	0.04
Test Anxiety	3.58	0.005
Elaboration	4.87	<0.0001
Metacognitive self-regulation	3.50	<0.0001

Table 15 – MSLQ Scale Scores for Each Self-Reported Usage Group

	Self reported usage			
Scale	Never N=5	<1 per week N=18	1-5 per weerk N=46	>5 per week N=12
Intrinsic Motivation	5.35	5.38	5.37	5.35
Extrinsic Motivation	4.50	4.40	3.98	4.60
Test Anxiety	2.80	3.50	3.54	4.23
Elaboration	4.90	4.73	5.01	4.93
Metacognitive self-regulation	4.00	3.30	3.56	3.69

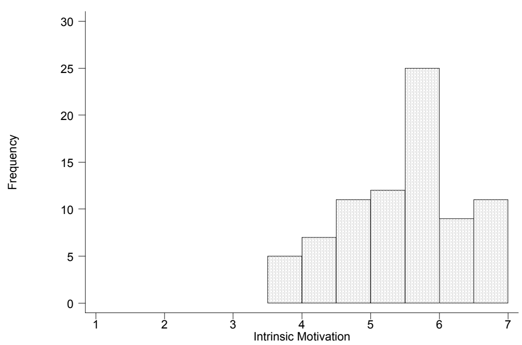

Fig 12 – Distribution of Intrinsic Motivation Scores

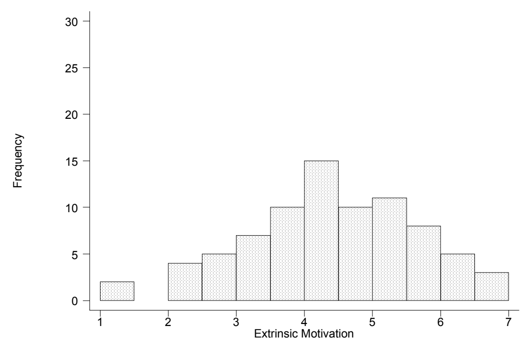

Fig 13 – Distribution of Extrinsic Motivation Scores

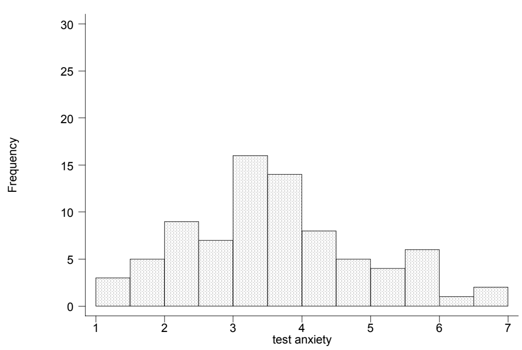

Fig 14 - Distribution of Test Anxiety Scores

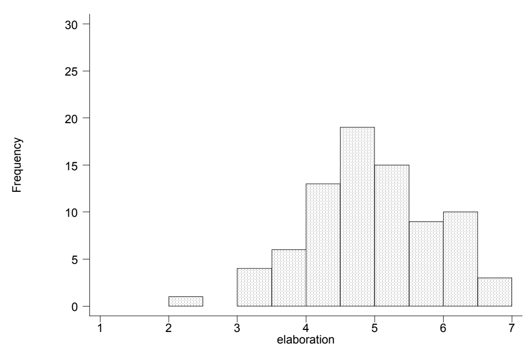

Fig 15 – Distribution of Elaboration Scores

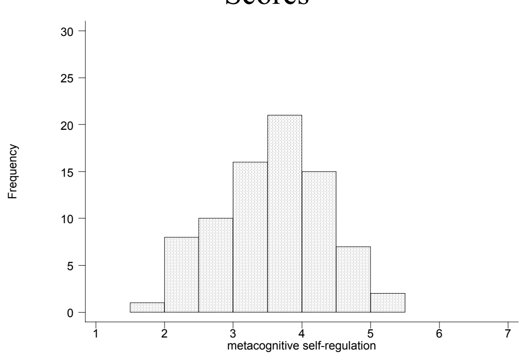

Fig 16 – Distribution of Metacognitive Self-Regulation Scores

There was an observed increasing trend in early adoption of the system with increasing test-anxiety scores. Similar to the analysis pertaining to computer proficiency, with increasing test anxiety score, the overall log-on days number was increased, the date of first log-in decreased, and 'adjusted' log-on frequency remained somewhat constant. This indicates that students with higher test-anxiety score may have started to use the system earlier, with the subsequent usage pattern remaining homogenous. (Figs 20-22 and Table 16)

Table 16 – Usage Statistic Comparison Between Different Test Anxiety Groups

	Test Anxiety Score			
	Low 1/3	Mid 1/3	High 1/3	p-value
Log-on days	11.4	13.5	20.5	0.02
First Log-on day	42.4	27.1	22.7	0.18
'Adjusted' Log-on frequency	0.17	0.16	0.22	0.21

Students with higher Elaboration scores tend to perform more string searches on KM (p=0.6)

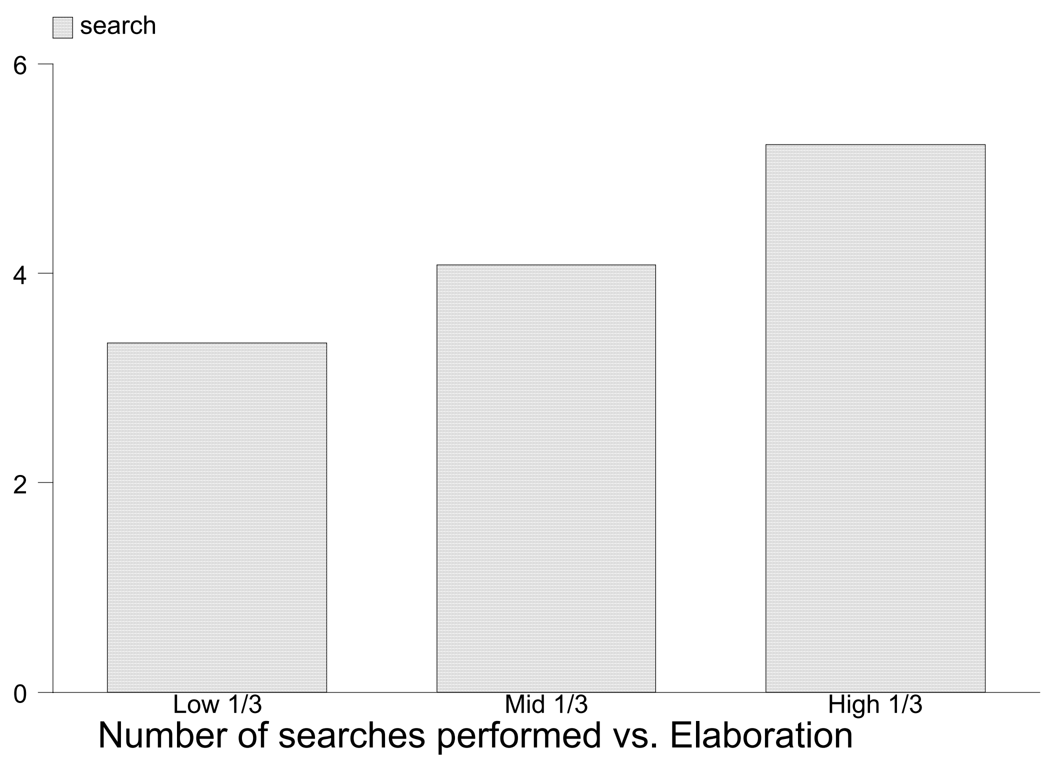

Fig 17 – Mean Number of Searches for Each "Elaboration Group"

Free form comments

Table 13 displays data from free form comments. A review of the comments revealed several themes. The percentages of total responders who made a comment related to a theme are shown below. (A & B)

Table 17 – Fraction of Occurrence of Most Common Free Form Comments

More PowerPoint®-like Features* (22%)
More Courses Integrated (21%)
Reduce Server Downtime (21%)
Reduce Lag Between Actual Lecture & KM Posting (19%)
More Speed (16%)
Access to Old Tests & Quizzes (13%)
Access to Web-Based Sources (10%)
More Reliable Loading (7%)
Audio/Visual of Lectures (7%)
Message Boards and Conferences (6%)

"More PowerPoint™ - like features", indicated by * in the table, refers to an inherent inflexibility of browsing PowerPoint slides online.

CHAPTER V

RESULTS – STUDENT INTERVIEWS

Ten students were interviewed. The topics covered within the interviews were grouped in two major headings: "The KnowledgeMap Application", and "Learning with KnowledgeMap". The former covers topics that relate to the students' usage of KnowledgeMap. Under the latter we will report how students viewed KM as pertaining to their learning experience. Complete summary of interview data is presented in Appendix F.

The KnowledgeMap Application

Nine students reported using KnowledgeMap. The interviewed student who had not used KnowledgeMap happened to be the only person in the class who never logged to the system during the data collection interval. His only encounter with the system was in a group study when another student in the group logged on. They encountered a technical error and abandoned using KM then. That student made cautious remarks about the increased roles of computers in education, e.g. "I don't think it is necessarily good to always be increasing the amount of time we spend in front of a computer monitor."

The nine students who used KnowledgeMap reported using it primarily to revisit class slides and notes, noting that, in general, their use of the system increased during the last few days before an exam. They had no difficulty learning to use the system. "I think most people our generation know how to use things like that." All students reported being comfortable and proficient at performing routine computer tasks such as browsing and using email, using Microsoft office, searching the literature and retrieving academic information. Five students have had some programming or web page design experience.

On technical issues, six of the students mentioned that they were affected by the server downtime on the eve of the second exam. Six students complained about the inflexibility of PowerPoint presentations when viewed in HTML. One of the three students who indicated dissatisfaction on the class survey was among those interviewed (fact not known during interview time). When asked about grievances with the system, that student reported that the system breaking down on the eve of the second exam was the most prominent. That student also reported logging on to KM frequently and said at another point in the interview generally about KM that "I do like it. I think it's very helpful, and I don't know how I would get through without it". That student scored the highest possible test anxiety score. (only 2 out of 81 survey responders had that score).

Concerning general attitudes towards computers, 10 students regarded them as valuable means of obtaining scientific information. Three students were concerned that the ease with which computers provide information may lead to heightened expectations from them to assimilate even more information. Among the favorable views heard are that online availability of lectures offers "consistency" in delivering equal information to all students, and that online access offers a sense of "freedom and mobility" to access lectures and information from any location. One student cautioned that with increasing reliance on computers in education there may not be a "level playing field" for students who are not computer savvy, and suggested offering training to incoming student lacking computer skills. Five students saw computers in the personal study environment as being potentially distracting. One student was too distracted by online gaming that at one point that student considered terminating high speed internet access at home but decided against that because of KM.

The student, who reported dissatisfaction on the survey, said "I didn't come here with a computer and I think that really *really* hurt my first year semester performance," and added that he/she was buying one the week after the interview. Of the other students, no one reported feeling pressured to acquire any computers. Another student reported being "sort of sick" of having to come to the library to check out a laptop to view the anatomy slides and thus acquired a laptop, but he/she said that it was a personal choice and that he/she did not feel pressured.

Among the items on the students' wish list for KnowledgeMap are: having more courses online, easier to navigate slide presentations, having extensive links to external resources (articles, glossary, other lectures, image base, illustrative case examples), better reliability and speed. Concerning their aspirations for the future of computers in medical education, students wished for, among other things, interconnectedness between different educational resources, one point access and seamless transition between knowledge content, smarter simpler interfaces, and portability (e.g. wireless PocketPC on wards).

Learning with Knowledge Map.

Four students said that KM did or probably did decrease their class attendance. Those students and three others were in agreement about not feeling the need to attend classes where the instructor is merely reading out of a slide or a lecture handout. One student said that he prefers to attend classes regardless of teaching style because classroom “jokes”, “anecdotes” or even instructor “mannerisms” would help him retain the information presented. Some students think that having complete notes available to students regardless of whether they were printed or online is what affects classroom attendance. When asked their *opinion about* class attendance being affected by KM. All students but one (the one who had not used KM) thought of the matter as a “personal choice” and “learning style”. The student who attends classes because of “mannerisms” argued that educators should not care. “If we achieve the goal does it matter so much if we don’t do it that particular way?”

Students reported that typically they assembled in groups as they approached exam time in classrooms with overhead projectors and went through slide presentations of anatomy with their peers while learning the material. Some appreciated the availability of slide presentations especially because the anatomy instructors prepare slides that are rich in pictures. One student said that teachers often include pictures from books that students don’t own. That student appreciates having access to those pictures rather than “buying 10 books for each class”.

With regards to the individual students learning styles, portions of the interviews that reveal the students’ “monitoring, planning, and regulatory”, processes that make up metacognitive self-regulation, were identified. Passages from all student interviews indicated sophisticated knowledge of themselves as learners, such as the statement by one student that he actively seeks out “stories” behind every concept because to him, things “stick better” this way. Another student adapts his learning style to each class because he is aware of the difference between a doctor’s “frame of reference” and the anatomist’s “frame of reference”. There were also instances that indicate “elaboration” strategies, strategies that help students store information into long-term memory by building internal connections between items to be learned. “I play it by games.” […] “trying to make up scenarios on my own and trying to figure out the results of dysfunctions. That helps me synthesize and figure out and understand it.” The nature and format of the anatomy course made it is difficult sometimes to integrate topics. “They put two sentences about the lymph in each lecture, so if you just look at one it doesn't make any sense. I remember trying to go through them with a friend and we were confused because there were 10 or so lectures, and each had a sentence or two of lymph somewhere in them, and then trying to tie it all together was just a mess we didn't know anything about it."

Topics are often related to those that are found in other courses. Students mentioned going back to their anatomy and biochemistry course during their spring physiology course to review pertinent information e.g. one student looked up catecholamine structure and SA node anatomical location during the cardiophysiology segment. (reminder: interviews took place early in the second semester). Many students said that such multiple-course integrations, although potentially helpful, did not take place during the anatomy course. "No, I was trying to memorize the individual lectures. I never got to that point." "I think that that doesn't really help you in your performance. If anything it would be somewhat harmful because you won't be memorizing the detailed notes if you were thinking of more general concepts." Limitations on time, and the large number of topics covered, forced some of the students to rely on "blatant memorization" rather than the aforementioned strategies that foster long-term retention. "I just move on because I don't want to waste the time confusing myself and looking through piles of notes trying to find something that may not be important." "I'm one of those who think that trying to solve problems in the 1st two months of medical school and trying to figure out all things that make up that problem and trying to solve it... is not a good idea. I'd rather have the base knowledge, or at least begin to learn it and be able to talk about it, and then... as far as I understand, in second year you begin to get some of these problems, and start to use that knowledge and bring it together to... sort of a more cohesive whole."… "its too easy to get lost"

A question that was asked to the students assumed that there is a dichotomy in one's approach to learning medicine, trying to be a "successful doctor", i.e. taking the time to integrate knowledge into a big picture, versus being a "successful student" i.e. focusing on the minute details of the courses as needed for the exams. The students were asked which of the two they would chose: Four students chose the latter, two students chose the former, and the remaining four students' answers indicated that they didn't view the situation as a mere dichotomy as that question suggests. "My goal for right now is to learn what I need to know for this next exam. […] But I also realize that you have to see the stuff 8 or 9 times before you really know how to use it. And this is just really the first pass. So try to learn as much of it now, and do it later, and do it again and again..."

The students were asked whether KnowledgeMap might help with condensed coursework situations where students feel compelled to sacrifice some learning strategies in exchange for short term retention tactics i.e. by reducing the time cost of searching through “piles of notes” or by simply making available upper year materials that students did not have access to before KM. None of the students mentioned relying on KM for such a purpose. Some have never done any searches, while others did limited searches in specific situations. “To me its basically a resource that just puts classes available online.” “I think that what I'm more concerned when I go on KM is to find information that is directly related to my upcoming exam, and since the 3rd and 4th year curriculum won't be on my physiology exam on Thursday then I'm really not interested in it when I'm on KM.”

Unanimously, the students saw the potential value of KM in the future for doing retrospective searches, e.g. bringing up basic science lectures online when the students will get to the wards. “I don't think I will be able to find my biochemistry notes in third and fourth years. But if it were on a computer, that will be much easier.” In contrast, however, most did not see much value in doing prospective searches as part of their routine learning. We asked the students whether they would like to have access to upper years course material. (which they did. In the fall of 2002, they did had access to around 1000 1st through 4th year documents). They provided mixed responses. Some students were weary of irrelevant information misleading them down non-fruitful paths. Other students had similar concerns.

A common theme that emerged was that information from upper year medical students could be curated by their professor and presented to them through a medium like KM as part of their curriculum. “One thing the professors could maybe do on KM, is make a list of primary sources that you could click on and read the articles so you would know what's accurate and relevant and what they want you to get out of it. Maybe just have a clinical correlation or an example of a patient with a problem with their knee when we're studying joints or something.”

“Seems to me that the greatest advantage of having things online is to be able to link them and be able to see all the things that are related. Right now I know KM is trying to incorporate that into medical education... but right now that's not the way it is. There aren't any slides online where you see 'this is an example of such and such' or 'to read more about this, click here' [....] that would be really nice. Ideally, I'd love to see that”

CHAPTER VI

RESULTS – FACULTY INTERVIEWS

This section will be divided into two parts, “The KnowledgeMap Application” and “Teaching with KM”. The former will report on discussions that relate to their usage of KnowledgeMap. The latter will report on portions of the interviews that discussed medical instruction and how it may have been affected by KM. Complete summary of interview data is presented in Appendix G.

The KnowledgeMap Application:

All interviewed faculty (6) had used KM. Three faculty members had used the search capability to a limited extent within the anatomy course. Although they appreciated the potential value of search across the curriculum to their teaching roles, none had done that by the time of the interview. They used their own personal computers over the web and did not need any extra equipment or facilities to be able to access KM. One professor lauded the ability to upload her presentations from home. More than one professor remarked that it was common for them to be asked by students about the online availability of their lectures.

All professors said the system was intuitive and user friendly. “Its pretty much self explanatory if you know anything about computers. If anything, just go to the 'search' option or the 'browse' option and see what's available.” One professor appreciated the fact that one could just “drop things” onto KM as opposed to the more complicated problems she faced with another course website that she maintained. Three professors said that it was helpful that the KM team showed up at an anatomy faculty meeting and went over the application with them before the beginning of classes. One professor had a problem where a presentation that he had uploaded and which was, for technical reasons, not available for students. “That was really frustrating.” The faculty knew that the system was down at a critical time before the 2nd exam and were concerned that that may have affected the students.

There was a lag time during the anatomy course between the time that lectures were uploaded and the time that they were made available to the students. The faculty had repeatedly expressed frustration during the course at that. A consequence of this problem was the problem that making changes to an existing document was inflexible. “I was giving the skin lecture and I said hydrophobic instead of hydrophilic. I just had it reversed. But it was just one slide, and just one error, but it's a pivotal error, you know. And it bothered me that I could have gone right back and changed it. [...] It's a small error, and I corrected it in class, and if they were there they would have heard it!”

The overall volume of emails that concern technical support during the class was 169 emails. More than 100 of those were communications between the KM team and the professors. The following is an excerpt from an email sent to us by one of the professors:

“I have received some complaints from students about not having access to our Power Point presentations immediately after they are given. That is one of the problems with today’s technology. While last year’s student had no access, this year’s students are upset because they don’t have instant access!”

All professors expressed overall satisfaction with the system. The professors were asked how they perceived student feedback. “We didn't have really that much feedback from the students. The only feedback that we really had was "hey I can't pull up your lecture". Which is great, I mean you'd love to have that feedback because then you know there's a problem and then you got to address that problem.”

All professors reported moderate to advanced computer skills. The course director has extensive experience in CAI in anatomy. When we interviewed him at his office, he was working on authoring an interactive anatomy atlas. Other professors reported that hundreds of hours of preparation may have gone into his slide presentations which he uses to create elaborate and sophisticated animations to illustrate complex anatomical concepts for his students. Two other professors have directly maintained websites for their courses. Yet another professor has extensive expertise in image processing software that is employed for research. All professors reported proficiency and reliance on internet searches both for didactic and research purposes. One professor called for an image base where normal and abnormal specimen pictures could be stored and shared across the curriculum. This comprehensive image base would bypass the need to obtain copyrighted images from books.

Teaching with KnowledgeMap

The faculty members were asked whether they perceived concrete effects of KM on their instruction. One professor noticed an increase in student email questions to him. More and more students sent him specific questions on his slides.

The first day that the KM team met with the anatomy faculty (prior to beginning of class), the subject of class attendance was raised as a potential concern. The concern was raised based on prior experience with co-op note-taking in embryology lectures drastically decreasing class attendance in a previous year. “Yes I think it (KM) will affect class attendance,” said one professor. Another professor agreed with that concern. “I think attendance would be one thing I'd bring up. You know, you worry if they have everything already then why show?”. “But,” he added “that's also an issue that the educator needs to have with himself. If they're not presenting the information in a way that's stimulating the knowledge acquisition by the students, then they're not effective in what they're doing. So something needs to change. It might be a good thing.” That professor saw decreasing attendance as part of a bigger loss of interaction that may result from something like KM. “whether or not that's a good thing would depend... to whom you're speaking. Like I think that's a bad thing because I like the student interactions, others would love it because they don't want to be bothered by questions all the time.”

They were asked whether they actually did perceive decreasing attendance. “I haven't detected, any negative effects. We're still having students come to class pretty much. When we used to have the old exams available, I would see negative effects from that. Because they would not study the notes, they would not listen to the lecture, and they would just study the old exams.” Another professor said “I don't think there has been a decrease in attendance. But I don't have any objective way to tell you that, just have a subjective feeling that I don't think there's been a decrease. Now, could that be a problem in the future? I think if you don't have people who are good lecturers that may be a problem. If they're really dry or something.”

Throughout the interviews the professors seemed to agree on the existence of a strain between making one’s lectures interesting and attractive to avoid attendance drain, and between handing out and adhering to complete notes that cover the entire topics discussed in class. “I'm just spontaneously teaching about the topic... They don't like that. They don't like anything that's not written down already, because it might be on the exam. So I've changed my teaching style, and I'm not happy with it”

Another professor abstracted this strain to being the educational question of whether teaching should pursue active learning strategies versus providing complete outlines that "spoon feed" and protect the students from being overwhelmed. "Its sort of hard to know. I would like them to be stimulated and motivated" […] "On the other hand I think there are those students that are overwhelmed by the volume of the material and they feel more secure if they had a handout that tells them what they need to know... and so its kind of a balance. Its not that they're not motivated enough, its just that they may not be able to handle the load. [Pause] See I am concerned, because we give them all this stuff, *could* they go and look up CHF (congestive heart failure) and find out all the information that they need? Would they *know* how to do that?" Another professor said "I don't want to make a problem based curriculum. I want to add that as a facet of learning." […] "Our curriculum has become too much: lecture based, powerpoint, lecture note. Its gotten all too rigid."

We asked them about the value they perceive of KM in this context of active information retrieval. One professor said that this value may be evident in the future in courses like pathology. "They'll go back to those individual powerpoint presentations and bring them up, and I know that there are second year students who went back and revisited those.[4]" "It may be easier to see the pictures on the PowerPoint™ presentation in the exact context in which it was given to them."

One professor said that it will benefit the students when basic and clinical professors do curriculum searches. "I think that would be very beneficial. It would be interesting to see what kind of lectures and what information they get presented, for example, in orthopedics or in neurosurgery for me" [...] "Just to see what they're exposed to, because I really couldn't tell you. Because I'd have to sit in on the classes, and as much as I'd like to, I just don't have the chance to do that." "It will be nice, if nothing else, just to get on KnowledgeMap and just see some of the topics and see how in depth they [clinicians] go with it. And I think it would be interesting to them to be able to come in to the basic sciences and see what these kids get in anatomy."

"I also want to be sure that I'm in sync with what's being said clinically. Make sure that its correct and clinically relevant and that I'm saying the right thing. When I first came as a new faculty, I was asked to give (a specific lecture in pathology) I was horrified, because I couldn't find out whether anybody else was teaching it?" […] "what and where to start? Because I had to

[4] In the fall of 2002, all VMS students had access to KM.

start from ground one. And I didn't have anything to build on, and I was really insecure about it. I think, especially young faculty, need to know what's being taught in other courses." "If you can just go to your computer, turn on the web and find out, that's wonderful!! You can go talk to that person!"

Two professors were concerned about copyright-related issues. "I guess I kind of made sure that nothing was taken out of context from a book, you know, exactly. The images were credited and I made sure that whenever images were used, or special words were used, that were used in a textbook and may not have been something that we normally would call something. Those were highlighted and we put parentheses and accredit them with appropriate credits. We were just concerned that a lot of times we write down things so that we remember them or present them in a clear and concise manner and they could be direct quotes out of a book. We just want to give credit where credit was due, and I think we are all concerned what things might get shoved off of KM where people have access to things, through the web" The other professor said, "I don't have permission to use that (image) even if I cite which textbook and which page it came out of. You're supposed to get permission to use it. So it will be a problem, the more people will have access to it. I'm concerned about stealing their stuff. They're editors, they want me to buy the book. One of us buys the book? We check the book out of the library, we scan it in, and we would have stolen their book without having to buy it. It's a problem, and I don't know how to deal with that! [...] Copyright issues are not solved! [...] If this is going to be a problem, I'm not going to do it! [laughs]."

Some professors were concerned about *their own* intellectual rights. "I think that it is important that if you spend an hour animating one particular slide that's very intricate, that somebody just doesn't take it and put into their presentation and say it's theirs," said one professor citing the amount of work that the anatomy course director spends on his slides. "And that's something that we're working here among the staff. Before, all the information was 'our information' in a general term. But now that people are putting tons of times, we're starting to cite those people."

Some discussed the complex nature of intellectual rights in their academic setting. "I feel that I've put a lot of time and effort into my presentations, and I would like for that to be acknowledged." […] "Depending on your subject matter, anatomy and histology have not changed in so many years and so it's very difficult to describe epithelium... other than what it is!

And so you can read my handouts and you can read all the textbooks and all the anatomy books and they all say the same thing. And so I don't want it to be misconstrued that I've stolen or I took something when I worked very hard trying to bring several concepts in and around together. Because it's surely not my intention. I'm not benefiting off of any of the handouts that I've given anybody, its just work that I've done to make sure that the point gets across correctly. So I'm not trying to steal other people's information and I don't want my information stolen."

A professor explained that from year to year, instructors swap specific lectures and hand over the PowerPoint™ presentations. "I guess that may raise a plagiarism issue on our side." "If I have a lecture that another professor gave last year, I will modify that lecture and try to improve it. Everybody's work is a work in progress. Some of us have a more finished work than others but, you know, we have errors." "At what point it becomes mine? No longer his and becomes mine? And that's a question we need to sit down with the course instructors. That's why you brought it to a head. *Because of KM, we had to sit down and have a course meeting and decide 'Who owns it?'*[5] I don't know! Because if I change it fifty percent, I've changed it. If I just change it five percent and I put my name on it, and he's spent gazillion hours preparing it. It's not fair, I shouldn't pass it as mine! These are the new ethical questions that we need to wrestle with."

KnowledgeMap makes the lectures that professors prepare available for scrutiny by the entire medical school. One professor said that on one hand she feels that her work readily available makes her vulnerable to unfair comparisons, e.g. during annual reviews, to fancier presentation prepared in other courses. However she added that being publicly available "could be a benefit because people also recognize your notes and what your contributions are." Another professor said "I don't have a single lecture in my arsenal, of around 30 lectures, that I consider a final product." "I want to add to what I have, and supplement it, and modify it, and tweak it, and improve it. I think the visual impact of the page itself could need some thought as well, the colors and the organization and the busy-ness of it. I think there's... the art of it, the science of it, the accuracy of it. There's lot of facets to it and I'm not pleased with any of the ones that I created. They were all created under the gun the night before and finished up in the wee hours of the night because I had to give the lecture the next day. They had some spelling errors in them; they have images that are not optimized. I canned them in as fast as I could. I got the image there

[5] Emphasis added

and we got the lecture done. They're not what I consider, publication format. And I really don't like having them out there! [Enunciated last sentence]" "I'm not a surgeon, if I'm talking about the surgical relevance of my lecture I may be out of date. I need to check my facts."

None of the professors modified the vocabulary in their lectures based on the knowledge that the slides and handouts will be indexed for online searches.

Finally, some professors remarked that it is becoming increasingly essential, for an educator, to possess information technology skills. "I think now, to make yourself more marketable as an educator, you really have to be involved with all these multimedia presentations." Another professor said, "I'm sure that one thing is true: change. I'm not the most computer literate person in the world, I know how to do what I need to do and not necessarily more than that, but being forced to do PowerPoint presentations when you've never had to do them before is a daunting task. And once you learn how to do a PowerPoint presentation is great but then learning how to animate them is another totally different thing. And so each year we try to do a lot of new things… to add on... and it could be a daunting task if you're not exposed to these kinds of things before."

CHAPTER VII

DISCUSSION

The authors of this study report the implementation of KnowledgeMap into a first year anatomy course. Student and faculty participants were found to be facile computer users who appreciated the potential for computers to support education and found KM to be user friendly. Nearly all first-year students used KM. Those with higher computer proficiency adopted KM earlier, but once a student started using KM, he or she would generally use KM just as frequently as an advanced user. Similarly, students with higher Test Anxiety Score tend to adopt the system earlier. Students appreciated having access to their course documents. Some reported reviewing the material before lecture, others would use KM soon after lectures to cement their understanding of what was just taught. Most students found KM helpful to review for upcoming tests. Heavy usage of KM clustered in the last few days before exams. Before exams, students formed study groups to review documents and slides displayed on KM.

Similar to the study by McNulty et al, good general concordance was found between the self-reported log-on frequency and the true one obtained from the web server. In general, students with lower log-on frequencies better estimated their usage frequency than those with higher usage. Students may have underestimated their frequency of logon to the system due to the fact that there are "blank" weeks such as time when they're on vacation or preparing for another topic.

The majority of students and all of the faculty members were satisfied with the system. The students who were neutral to the system are those who used it very little. When comparing high vs. low usage students, high usage students were found to be more frustrated with technical errors and felt that technical errors prevented them from accessing information when they needed to. This finding is compatible with the hypothesis that technical errors, although frustrating, did not lead to a lower adoption rate.

Students who did not own a computer at home at the time of study, showed significantly later adoption and expressed more neutral attitudes towards the system. However, they also had a significantly lower computer proficiency score. When controlling for proficiency level, both satisfaction and adoption time showed no significant difference between those who own a computer and those who don't. This points towards a confounding effect of computer proficiency on computer ownership and on usage of the system. The relatively small number of students who don't own a computer (7/72) prevents a more detailed analysis of computer ownership as an independent factor for usage. Whether computer ownership is an independent factor or not, it still remains necessary for an institution that adopts a computer system for instruction to be considerate of the needs of students that do not own a computer (10% of survey responders).

Despite awareness and appreciation of KM's ability to show all concepts taught in the medical school, the students were only interested in what KM brought to bear in the current course. They did have access to hundreds of upper year course materials at the time of the study, but the log files indicated only a minute amount of searching activity. The students browsed KM for course information 20 times more than they searched KM for concepts. Using the MSLQ tool, we detected a slight increase in "searching" for documents with increased Elaboration Score. From interviews we found that students recognized the value of elaborating on current information as a learning strategy that augments understanding and retention. Interviews with students confirmed that time and performance pressures force one to focus on the "here and now" rather than look to future curriculum material to gain insight as to how the anatomy course fits with future learning. The first year medical students considered that their searches would yield much information from future courses, information about which they would know little. The numerous concepts not yet comprehensible to them from upper year courses constitute "noise" that masks what they are searching for. Instead, they favored having their teachers provide explicit links to future course material rather than taking on that responsibility on their own through KM searches. Students reported the search features of KM to be more valuable as one progressed through the curriculum to "look back" for items previously covered that may be valuable to the current learning need.

Discussions about class attendance brought up important issues about the function of the lecturer and the handout. Different opinions arose. Some students want lecturers to follow the handout and slides verbatim in order to provide clarity. Other students argue, "why go to lecture" if they are just going to read the handout. In their opinion, lecturers should not just disseminate information, they should teach for understanding. In addition, the enthusiasm and personal expressions of their teachers helped many students gain a better appreciation and understanding of the material. Faculty members basically agreed. They know that sparse handouts to students are reflected negatively in course evaluation. More detailed notes are necessary. Yet lecturers should provide more than the information in the handout or slide show. If not, they admitted, dwindling class attendance should not surprise them. Lecturers should express their attitudes about the material, provide examples and questions for going further. Students, they said, should not be surprised to find material not covered in the handout on the exam, for it was covered in the lecture. Nevertheless, both students and faculty members applauded the value of KM to display the handouts and slides of each lecture to ensure an adequate amount of detail is made available at all times to students. During this study, faculty members did not discern an impact of KM on actual class attendance.

This question poses a strain since on one hand incomplete yet stimulating handouts are abandoned as a result of negative course evaluations, whereas, on the other hand, providing complete 'spoon-fed' notes to the students may lead to very little being offered by the instructor in class and hence dwindling attendance numbers. Note that this strain did exist, although in less prevalence, before the advent of electronic medium (co-op notes in embryology, complete printed handouts).

Whereas students viewed KM as a means to manage their current course, faculty members were more interested in searching KM for material in other courses. Faculty members desired to determine how their material fit into the overall curriculum. KM will help coordination among faculty members of different courses to optimize teaching of similar concepts and avoid redundancy. A new faculty member may use KM to find where his or her topic(s) is taught. KM would also help provide correct information to incorporate in one's course about a field in which they may be less familiar.

In many ways, implementation of KM raises expectations for students and faculty members. Given the computerization of the curriculum, some students voiced concern that there be a level field between computer-proficient and non-proficient students. Computer training will be necessary. Other students wondered if they could refrain from the distractions of the web while using the computer to study. Most students called for all courses to use KM. With growing use of KM, faculty members are faced with more scrutiny of their material. Faculty members interviewed wondered whether this would lengthen their preparation time to ensure even more precise, state of the arts information. Only one faculty member predicted more electronic links, hypermedia, and other computer tools to support medical education. She wonders whether she would have the expertise and time to adjust her lecture material to meet these heightened expectations. Another faculty member contemplated the wisdom of imposing a template on all faculty members to eliminate variability and relieve them from the uncertainty concerning quality of their electronic presentation being at the same level as everyone else.

With the arrival of KM, faculty members have renewed interest in making sure that they adhere to proper copyright laws and protect their own intellectual property. Individuals called for more training and assistance in understanding and carrying out appropriate policies. Having the lectures readily available for sharing and modification raised interesting questions among the faculty as to what exactly constitutes intellectual property of parts or all of an electronic educational document. "It was because of KM" that the anatomy course faculty met before the beginning of the semester to set guidelines on this issue.

CHAPTER VIII

CONCLUSION

KnowledgeMap introduced a new medium of instruction into the medical school. This medium of instruction is not an electronic replica of existing paper-based media. Instead it adds information retrieval capability through text-based searches and the ability to cross reference to other online sources of information.

Systems like Knowledge Map have the ability to transform the learning environment. KM partly redefined the borders of the lecture in time (can relive the lecture anytime) and space (as discovered from the discussion on attendance). Although first year students appreciated having the ability to search across the curriculum, they have elected to remain in the safety of their anatomy course. For that potential to materialize, they argued, faculty members had to supervise their forays into the clinical realm of senior classes. In a way, the role of faculty is expanded to include being a "curator" of a vast collection of readily available knowledge. More generally, as one student puts it, "physicians will be more of *skilled operators* than just *holders of knowledge"*.

KM has yet to achieve its full potential as an alternative medium of instruction. Students, more than faculty, pointed out that at this stage, the hypermedia capabilities of online lectures are still untapped. Instead of treating the computer screen as a mini-projection wall, faculty can embed in their lectures links to various resources including other lectures within the curriculum. This will endow the students with an efficient ability at their fingertips to pursue related interests, and –depending on their learning style- help them contextualize and buttress their knowledge. The medical curriculum will then be transformed from a flat repository of information into a rich network of knowledge. How this potential will be achieved, by whom exactly, and through what means remain open questions.

This research also unearthed many potential effects that KM could have on the medical school environment. They vary from faculty specific intellectual property concerns, to class attendance and the pressure to acquire personal computers. KM brought to the forefront an existing tension that relates to complete versus 'stimulating' lecture handouts. The aim of this research is not to determine the best course of action, but to detect all possible ways that such an innovation can affect the way medicine is taught, and to put this knowledge back in the hands of medical educators.

The developers of KM have learned that KM was used almost unanimously, and that the majority of students have expressed satisfaction with it. Specific needs of technical and design improvements were identified.

Students who are more proficient computer users and those who are more anxious about their class performance may have been faster to embrace this system. Frequent users did not accurately estimate the frequency of their use. It is safer to rely on actual usage data when possible.

Finally, this research embraced the investigative traditions of other disciplines that directly relate to medical education. The investigators have gained tremendously from this synergy. Friedman and Dev in an editorial in JAMIA [8] called for Medical Informatics to "join forces" with the education community. The authors of this study are heeding this call.

CHAPTER IX

EPILOGUE

Based on this study, the technical sources of error reported by the students have been addressed in the few months following the study. Several focus groups have been conducted with various groups of medical students, to incorporate their feedback into design and debugging. For example, we have added the ability to highlight a medical term and obtain a definition from a medical dictionary, and lectures and slides can now be formatted for printing. The web-based viewing of PowerPoint slides has been optimized in a way that adequately addressed the intellectual property concerns of faculty. KM now runs on multiple servers to distribute the load at peak usage times.

Since the conclusion of this study, most courses from all four curricular years have gone online and KM has been further adopted at the institutional level. For example it was used in a School of Medicine curricular retreat in February 2004, and has since been used by the medical school to monitor curricular content of various topics. This pilot experience provided the medical school officials with insights into the potential effect on instruction that may occur with the introduction of this new medium. Knowledge obtained from this study is being utilized in formulating policy concerning the use of KM and related application at Vanderbilt Medical School.

APPENDIX A

THE KNOWLEDGEMAP PROJECT

Capitalizing on the many recent advances in informatics and computer technology, researchers at Vanderbilt's department of medical informatics have constructed a web-based knowledge management tool to support medical instruction at the Vanderbilt Medical School [9, 10]. The stated goal of this tool is to promote online availability of educational resources, and make them available to faculty and students at various levels of their training thus helping to create a longitudinal integration of the medical curriculum. Knowledge Map is available to all VMS students.

KnowledgeMap – Concept Identifier

The concept identifier (henceforth referred to as KM-CI) grew out of the earlier work on the project, in an attempt to "understand" the medical curriculum and be able to perform meaningful searches on it. The KM concept identifier uses lexical tools derived from the SPECIALIST lexicon, heuristic natural language processing techniques, and a rigorous scoring algorithm to differentiate between ambiguous concepts. The researchers compared the performance of the KM concept identifier with the National Library of Medicine's MetaMap (MM) using selected subsets of curriculum documents from which the authors had identified key concepts manually. The results were published in the Journal of American Medical Informatics Association[10].

Of the 4274 gold standard concepts, MM matched 78% and KM 82%. Precision for gold standard concepts was 85% for MM and 88% for KM. KM's heuristics more accurately matched acronyms, concepts underspecified in the document, and ambiguous matches. The most frequent cause of matching failures was concept absence in the UMLS. Thus, KM-CI provides automatic extraction of concepts represented in medical educational texts.

KM-CI's potential

The development of KM-CI provided us with another potent tool that could analyze any free text and output a list of unique medical concepts, ranked by frequency, that are included in that documents. An example is that the phrases "congestive heart failure", and "dilated cardio-myopathy" – phrases that have no words in common – are mapped to the same concept "heart failure". This allows us to overcome some of the limitations of more traditional word-based indexing and searching of documents.

Virtually any biomedical text could be analyzed by KM-CI in the manner described above, although the formal evaluation was only performed on curricular documents. A potential application of this tool is to apply it to a corpus of documents and then construct concept- and word-indexes that point back to the individual documents. This allows for more robust searches to be performed on that group of documents.

The KnowledgeMap application

The first use of the KM-CI was put towards the stated goals of the KM project, namely the integration of the medical curriculum online. We approached various professors asking them to provide us with their educational material. We received good response and started by building the application around 650 documents spanning 18 courses. The documents were from the previous year and so were "free floating" in the system, i.e. not attached to any specific lecture date. We used them as a general backdrop for our search.

A web-based application was developed where students would log-on using their vunetids and e-passwords. We had decided to make the site secure to address some of the intellectual property concerns raised by the professors. A relational database model was developed to represent the various components that make up a 'medical school curriculum'. This includes such concepts as "lecture" "document" "course" "student" "faculty member" etc… The relational database supported the KM application as it served as a course management application for faculty and course directors. Course directors entered the weekly schedules onto KM, assigning lectures to professors. The individual lecturers would then log-on to the system and upload their documents (handouts + powerpoint presentations).

Figure 1 – course management

The uploaded documents are converted to HTML and presented in a manner that reflects the course's weekly schedule format so that students and other faculty can browse through them.

Once documents are uploaded, the KM-CI would analyze them for concepts. The concepts obtained from each document would be added to the overall site index. This comprehensive index allows us to give students the opportunity to do searches across the curriculum. In a text box, students enter their search phrase which we map to a vector of UMLS concepts and match that with all the documents we have in our repository. A list of matching documents is returned. When one clicks on a document in that list, the search concepts are highlighted.

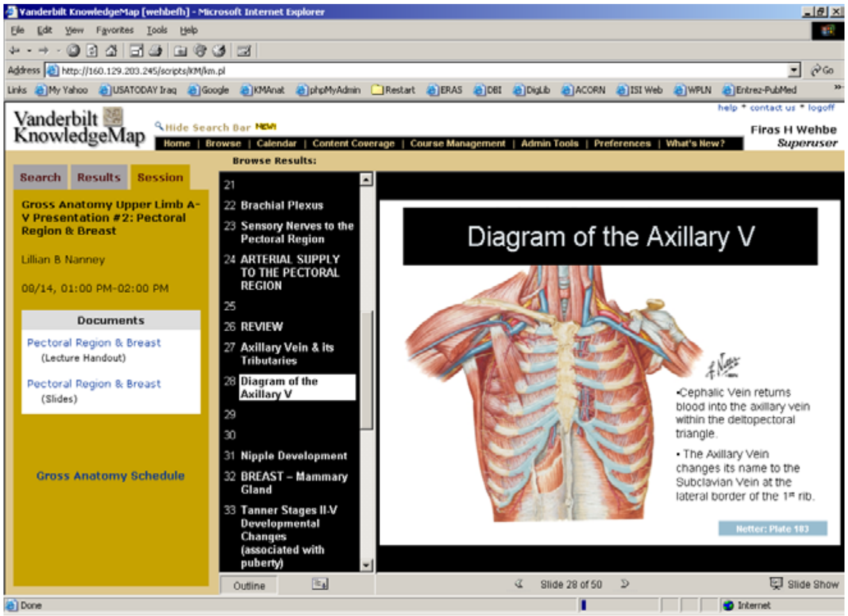

Figure 2 – browsing the course material

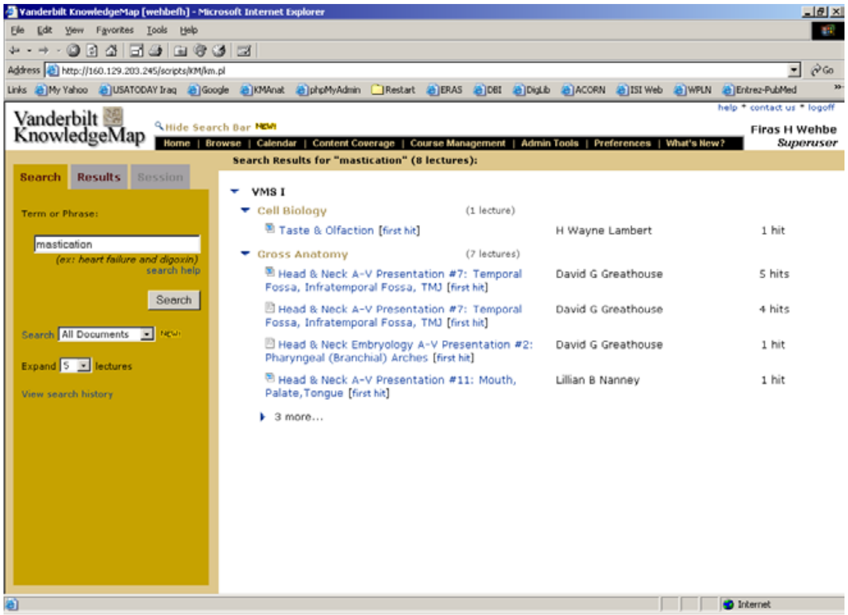

Figure 3 – search results

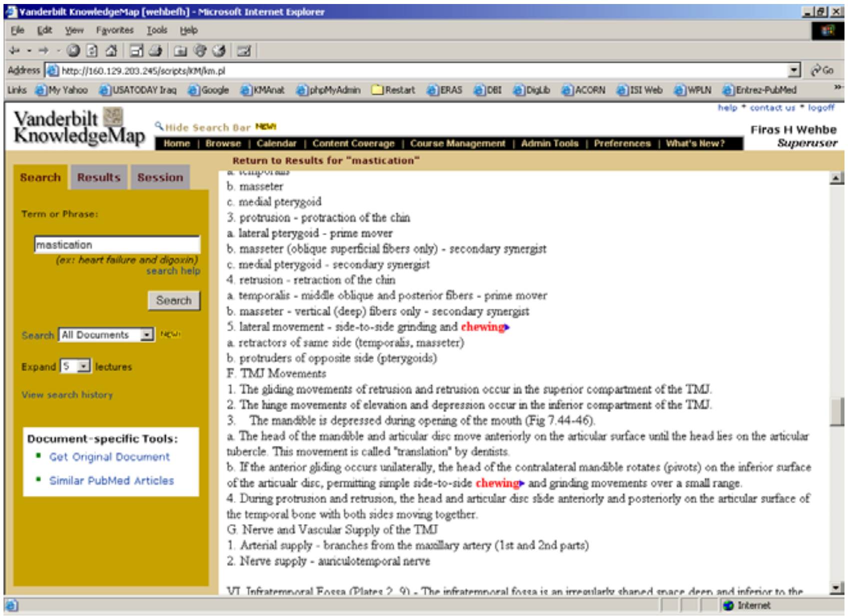

Figure 4 – notice how the term "chewing" is highlighted during a search on the string "mastication"

Please refer to the following paper[9] on the design and implementation of the KM web application, as well as a presentation of other KM features like PubMed searches. (Presented in the Fall 2003 AMIA Symposium)

Remark on browsing through slides converted to HTML: When MS-PowerPoint™ converts slide presentations to HTML format, Active X controls are embedded in the HTML codes. They aim to preserve the look and feel of a PowerPoint™ presentation in HTML, including slide and object transition effects. One shortcoming of this system is that one cannot "leap forward" or "backward" to other slides. Nor can full screen slide shows be launched starting from the middle of the presentation. Some of the anatomy slide presentations were over 100 slides long, and so someone seeking to view the slide show from one of the later slides would *have* to sit through the entire parade of slides – and their transition effects, already slower in HTML – starting from #1.

Content Coverage

One of the functionalities of the system is that it gives the administrators the ability to perform broad searches across the curriculum on general topics. This answers questions like "where is women's health taught across the curriculum? … or genetics?" The general concept is entered, and KM leverages the semantic network component of the UMLS to expand to related concepts. For instance, the concept "Genetics" would be expanded to its children concepts like "DNA", "molecular genetics", etc… The extent to which the broad concept is expanded can be controlled by the user and would hence give the ability to "tweak" the search. A general concept like "Radiology" or "Woman's Health" generally expands to a few thousand related concepts.

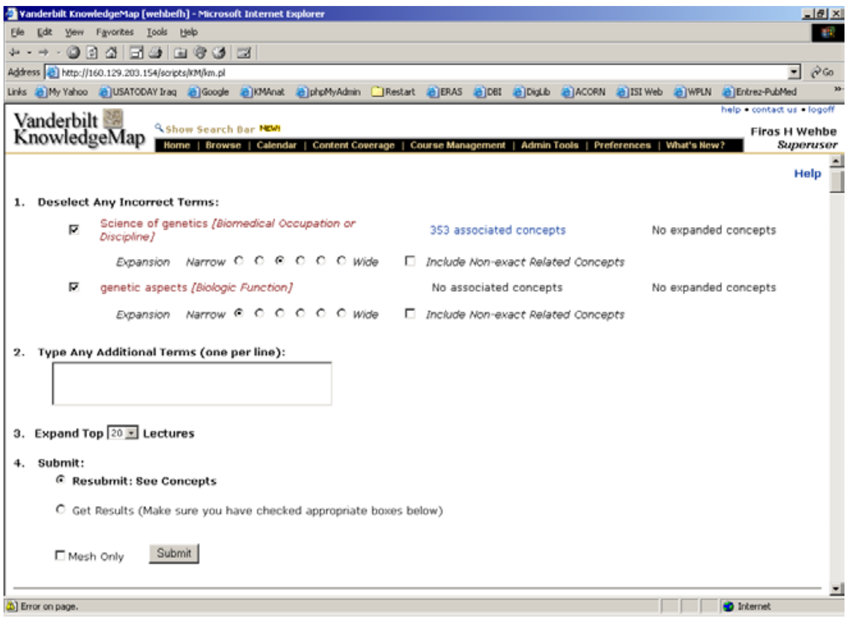

Figure 5 – Expansion of term "Genetics" in the Content Coverage tab

A research project is currently underway to see whether KM-CI can identify curricular documents as having high, low, or no content in any of 5 broad topics: Epidemiology, Radiology, Genetics, Women's Health, and Dermatology. A clinician went through 400 educational documents and classified them as high, low or no content in those five areas. Agreement studies will be performed using various parameters of the scoring algorithm.

Future directions:

There are many potential directions for future work on the KM project. One is along the capabilities of the KM – Application. Many interesting questions present themselves like more careful scrutiny of searching behavior of students, long term follow up of student usage, or even correlation studies between usage and performance on long term knowledge indicators like the board exams. This line of research would be more appealing to people whose interest lie in medical education, or medical school policy.

The other future direction is focused on the engine itself: KM – CI. Currently KM – CI operates using the 2001 version of UMLS files. Updates are constantly made to the UMLS and it would be interesting to see how the performance is changed *on the same set of documents* using subsequent versions of UMLS. Another research project could look at the lexical tools and disambiguation algorithms. These tools and algorithms are heuristic in nature and it would be interesting to gauge the performance of lexical vs. probabilistic vs. hybrid approaches.

A third line of research lies in information retrieval. KM – CI converts almost any flat free biomedical text to an ordered list of standardized UMLS concepts. This is true especially that the UMLS is flexible and is intended to have broad coverage over many Biomedical domains. By converting free text to a high dimensional vector (of concepts), KM – CI is essentially performing a pre-processing step for vector based information retrieval [117]. There exists numerous well described algorithms in the literature for vector based information retrieval. By applying such techniques, or even experimenting with our own, we can try to construct medical-text-retrieval applications that are more effective than existing ones.

APPENDIX B

SURVEY

Vanderbilt University

Department of Biomedical Informatics

KnowledgeMap Impact and Evaluation Questionnaire

Dear Student,

The Knowledge Map team is conducting a study on the use of Knowledge Map in your class. This study will help us determine future directions for the development of Knowledge Map. The information we want to collect through this survey is basic demographic information, computer skills and access, study strategy, and user satisfaction.

Your VUNet ID will be used to merge the answers from this survey with your usage data obtained from the Knowledge Map's technical log files. **After that point your VUNet ID will be removed from the questionnaire and stored separately.** Your VUNet ID, your response to this survey, and the usage data of your VUNet ID will be used solely for the purposes of this study.

Your participation in this research study is voluntary. You are also free to withdraw from this study at any time. Withdrawal or refusal to participate will not prejudice you in any way. In the event new information becomes available that may affect the risks or benefits associated with this research study or your willingness to participate in it, you will be notified so that you can make an informed decision whether or not to continue your participation in this study

Contact Information: If you should have any questions about this research study or security and privacy measures, please feel free to contact **Firas Wehbe** at **(615) 936-3016** or my Faculty Advisor**, Dr. Anderson Spickard-III** at **(615) 936-2078**.

For additional information about giving consent or your rights as a participant in this study, please feel free to contact the Vanderbilt University Institutional Review Board Office at (615) 322-2918 or toll free at (866) 224-8273.

Confidentiality: Reasonable efforts will be made to keep the personal information in your research record private and confidential but absolute confidentiality cannot be guaranteed. Your information may be shared with institutional and/or governmental authorities (for example, research auditing), if you or someone else is in danger or if we are required to do so by law.

By entering your VUNet ID below you indicate your free and voluntary consent to participate in this research.

VUNet ID

Questionnaire feedback (optional)

Parts of this survey are adopted from a psychology instrument – The Motivated Strategies for Learning Questionnaire (MSLQ). Five Scales will be calculated from your response. They are: Intrinsic Motivation, Extrinsic Motivation, Test Anxiety, Elaboration, and Metacognitive self-regulation. (refer to attached handout for an explanation on these scales). If you would like to view your score and percentile in class on these scales check the box below. Your individual results will be available to you only, and in secure form through Knowledge Map.

□ I would like to be able to view my score on the measured scales from MSLQ.

I. Satisfaction:

We want to know about your experience with KnowledgeMap.

1. Which of the following approximates your average frequency of **logging into** to the system?
    1. Zero – never used it
    2. Less than once every 2 weeks
    3. Less than once a week
    4. 1-5 times per week
    5. >5 times per week

2. Which of the following approximates the percentage of times you encountered **technical errors**[6]?
    1. 0-20% of the times I used KM
    2. 20-40% of the times I used KM
    3. 40-60% of the times I used KM
    4. 60-80% of the times I used KM
    5. Almost every time I used KM (80-100%)

3. Did you need to seek technical support from the site administration? Yes No

If yes then please answer the following 2 questions:
(1 = not at all true to me to **7 = very true of me)**

4	I received prompt attention to my need	1	2	3	4	5	6	7
5	My needs were met	1	2	3	4	5	6	7

Please rate your agreement with the following items based on your experience with Knowledge Map. Your rating should be on a 7-point scale where **1 = not at all true of me** to **7 = very true of me**

6	Download speed is an important factor for my satisfaction with the system	1	2	3	4	5	6	7
7	It is important to me that KM supports browsers other than Internet Explorer.	1	2	3	4	5	6	7
8	I would like to have the ability to download the lectures in their original file format – as opposed to HTML	1	2	3	4	5	6	7
9	I am frustrated by the technical errors	1	2	3	4	5	6	7
10	Technical errors made me use KM less frequently	1	2	3	4	5	6	7

[6] Examples of 'Technical Errors' include the **server being down, being directed to wrong pages, blank screens, troubles logging in, etc…** we are NOT referring to problems that occur on the user side such as the modem/phone line connection being too slow, the user's computer crashing, or having older versions of browsers that do not support KM.

11	Technical errors prevented me from accessing important information when I needed it.	1 2 3 4 5 6 7
12	I feel that there was a long time lag between the lecture presentations and the time they were made available online	1 2 3 4 5 6 7
13	**Browsing** documents and the class schedule was convenient and easy	1 2 3 4 5 6 7
14	Using KM to **search documents** by keywords was convenient and easy	1 2 3 4 5 6 7

List 3 things that Knowledge Map successfully provided:

____

____

____

List 3 things that you would like KM to provide that either are not currently available, or are available but don't work properly.

____

____

____

Overall how would you rate your satisfaction with KnowledgeMap?

Very dissatisfied	Somewhat dissatisfied	Neutral	Satisfied	Very Satisfied

II. Computer Skills

We need to know about your computer skills and background. Please rate how familiar you are with the following items.

	Somewhat familiar	**Familiar**	**Very familiar**
1. Typing:	☐	☐	☐
2. Copying, pasting text/graphics:	☐	☐	☐
3. Creating, moving directories/ files:	☐	☐	☐
4. Compressing files (Zip/unzip):	☐	☐	☐
5. Loading/downloading software, files :	☐	☐	☐
6. Creating handouts with tables:	☐	☐	☐
7. Using virus scans :	☐	☐	☐
8. Literature searching (eg MEDLINE):	☐	☐	☐
9. Efficient browsing the internet:	☐	☐	☐
10. Writing html language :	☐	☐	☐
11. Using Real Audio :	☐	☐	☐
12. FTP, mounting web pages :	☐	☐	☐
13. Data entry, spreadsheets :	☐	☐	☐
14. Email attachments :	☐	☐	☐
15. Creating PowerPoint Slides :	☐	☐	☐

16. Do you have computer at home? Yes No

17. What do you believe to be the effect of computers on your medical education?
    1. Very beneficial
    2. Somewhat beneficial
    3. Neither detrimental nor beneficial
    4. Somewhat detrimental
    5. Very detrimental

III. Study Strategies and Motivation:

Some of the following questions ask about your motivation for and attitudes about this class. Other questions ask about your learning strategies and study skills. Remember there are no right or wrong answers, just answer as accurately as possible. Use the scale below to answer the questions

1	2	3	4	5	6	7
Not at all true of me						very true of me

1	In a class like this, I prefer course material that really challenges me so I can learn new things.	1 2 3 4 5 6 7
2	When I take a test I think about how poorly I am doing compared with other students.	1 2 3 4 5 6 7
3	Getting a good grade in this class is the most satisfying thing for me right now.	1 2 3 4 5 6 7
4	When I take a test I think about items on other parts of the test I can't answer.	1 2 3 4 5 6 7
5	The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.	1 2 3 4 5 6 7
6	If I can, I want to get better grade in this class than most of the other students.	1 2 3 4 5 6 7
7	When I take tests I think of the consequences of failing.	1 2 3 4 5 6 7
8	In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.	1 2 3 4 5 6 7
9	I have an uneasy, upset feeling when I take an exam.	1 2 3 4 5 6 7
10	The most satisfying thing for me is trying to learn the content as thoroughly as possible.	1 2 3 4 5 6 7
11	When I have the opportunity in this class, I choose to do work that I can learn from even if it doesn't guarantee a good grade.	1 2 3 4 5 6 7
12	I feel my heart beating fast when I take an exam.	1 2 3 4 5 6 7
13	I want to do well in this class because it is important to show my ability to my family, friends, employers, or others.	1 2 3 4 5 6 7
14	During class time I often miss important points because I'm thinking of other things	1 2 3 4 5 6 7
15	When reading for this course I make up questions to help focus my reading	1 2 3 4 5 6 7
16	When I become confused about something I'm reading for this class, I go back and try to figure it	1 2 3 4 5 6 7

	out	
17	If course materials are difficult to understand, I change the way I read the material	1 2 3 4 5 6 7
18	When I study for this class I pull together information from different sources, such as lecture notes, books, discussions, lab sessions, and online resources.	1 2 3 4 5 6 7
19	Before I study new course material thoroughly, I often skim it to see how it is organized	1 2 3 4 5 6 7
20	I ask myself questions to make sure I understand the material I have been studying in this class	1 2 3 4 5 6 7
21	I try to change the way I study in order to fit the course requirements and instructor's teaching style	1 2 3 4 5 6 7
22	I often find that I have been reading for class but don't know what it was all about	1 2 3 4 5 6 7
23	I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying	1 2 3 4 5 6 7
24	I try to relate ideas in this subject to those in other courses whenever possible	1 2 3 4 5 6 7
25	When I read for this course, I try to relate the material to what I already know.	1 2 3 4 5 6 7
26	When I study for this course, I write brief summaries of the main ideas from the readings and the concepts from the lectures.	1 2 3 4 5 6 7
27	I try to understand the material in this class by making connections between the readings and the concepts from the lectures.	1 2 3 4 5 6 7
28	When studying for this course I try to determine which concepts I don't understand well	1 2 3 4 5 6 7
29	When I study for this class, I set goals for myself in order to direct my activities in each study period	1 2 3 4 5 6 7
30	If I get confused taking notes in class, I make sure I sort it out afterwards	1 2 3 4 5 6 7
31	I try to apply ideas from course readings in other class activities such as lectures and lab sessions.	1 2 3 4 5 6 7

IV. Demographics:

Age:	
Gender:	1. M 2. F
What is your current status	1. VMS 1 2. VMS (other - including MSTP) 3. Graduate Student

V. Comments

If you had a magic wand, what would you do to make KM better?

Anything else you'd like us to know?

APPENDIX C

CONSTRUCTS FROM MSLQ QUESTIONNAIRE

Goal orientation refers to the student's perception of the reasons why she is engaging in a learning task. On the MSLQ, goal orientation refers to student's general goals or orientation to the course as a whole. **Intrinsic goal orientation** concerns the degree to which the student perceives herself to be participating in a task for reasons such as challenge, curiosity, mastery. Having an intrinsic goal orientation towards an academic task indicates that the student's participation in the task is an end all to itself, rather than participation being a means to an end.

Extrinsic goal orientation complements intrinsic goal orientation, and concerns the degree to which the student perceives herself to be participating in a task for reasons such as grades, rewards, performance, evaluation by others, and competition. When one is high in extrinsic goal orientation, engaging in a learning task is the means to an end. The main concern the student has is related to issues that are not directly related to participating in the task itself (such as grades, rewards, comparing one's performance to that of others). Again, this refers to the general orientation to the course as a whole.

Test anxiety has been found to be negatively related to expectancies as well as academic performance. Test anxiety is thought to have two components: a worry, or cognitive component, and an emotionality component The worry component refers to students' negative thoughts that disrupt performance, while the emotionality component refers to affective and physiological arousal aspects of anxiety. Cognitive concern and preoccupation with performance have been found to be the greatest sources of performance decrement Training in the use of effective learning strategies and test-taking skills should help reduce the degree of anxiety.

Elaboration strategies help students store information into long-term memory by building internal connections between items to be learned. Elaboration strategies include paraphrasing, summarizing, creating analogies, and generative note-taking. These help the learner integrate and connect new information with prior knowledge.

Metacognition refers to the awareness, knowledge, and control of cognition. We have focused on the control and self-regulation aspects of metacognition on the MSLQ, not the knowledge aspect There are three general processes that make up **metacognitive self-regulatory activities**: planning, monitoring, and regulating. Planning activities such as goal setting and task analysis help to activate, or prime, relevant aspects of prior knowledge that make organizing and comprehending the material easier. Monitoring activities include tracking of one's attention as one reads, and self-testing and questioning: these assist the learner in understanding the material and integrating it with prior knowledge. Regulating refers to the fine-tuning and continuous adjustment of one's cognitive activities. Regulating activities are assumed to improve performance by assisting learners in checking and correcting their behavior as they proceed on a task.

APPENDIX D

STUDENT INTERVIEW PROTOCOL:

Computer Skill / Attitudes

- How would you describe your computer skills? (can ask specific questions: programming, PowerPoint, databases)
- Do you rely on computers when you study? How?
- Does using computers increase the amount of work you need to do?
- (if increase) Why do use computers then?
- Do you foresee an increase in the role of computers in learning? (if yes: Is this a positive or negative thing to you?)
- How do you think existing computer systems can be modified to better serve you?
- How much time did you spend learning to use KM?
- Was your home internet access an issue with KM? Did it affect your choice of technology purchase, or internet access? *{e.g. fast internet access vs dialup}*
- Did using knowledge map, in specific, increase or decrease the amount of work you had to do for anatomy?

KM & how you study

- Could you walk me through how you prepared for the anatomy course? (allow for details)
- Has KM affected your class attendance?
- How do you use online lectures for your course preparation?
- Did your note taking in class change by the knowledge that lectures are available online?
- During your preparation for the anatomy class, did you feel a need to have a computer close to you when you were studying? (if yes – what for? *{KM, other resources?}*)
- When you study, do you often try to think of practical applications of the knowledge you are acquiring?
- How do you try to determine the future relevance of what you are studying? *{ask senior students, reading, …}*
- Which is more important to you, knowledge of future applications of what you are studying, or knowledge of what is needed for exams? "If asked to choose, and this may rarely be the case: would you rather learn information that is relevant to you later as a doctor OR learn what will get you a better grade in the course?"

Information needs

- As a first year medical student, what do you think you should be learning other than what you are taught in class? What information do you want to have access to?
- What are the *sources* of information that you would use to supplement your course work?
- (probe if computers among sources listed)
- As a student, how can you envision an ideal situation where computers are used to provide your information needs?

- How do you think KM can be used for purposes mentioned above? *{goal of question is to assess extent of their knowledge of KM's potential applications like searching across courses…}*

"Integrated" curriculum

- How much would you agree with the following statement? "It is NECESSARY for me, as a first year medical student, to have access to course material from senior medical classes"
- Why? *{allow for elaborations}*
    - If agree
    - What would you like to get out of those course materials?
    - If disagree
    - Would it be confusing to you, if you look up future courses?
- Did you attempt to search in KM for relevant documents to what you were learning in Anatomy?
    - (if yes) How would you use relevant documents retrieved?
- How, do you think, will you review this course when you're at a later stage in medical school?
- Would be important to you to be able in the future to access course material in their ORIGINAL form?

Satisfaction & usability issues

- What are major disappointments/ dissatisfactions you had with using KM?
- Any other thoughts about your experience with KM?

APPENDIX E

FACULTY INTERVIEW PROTOCOL:

Computer Skill / Attitudes

- How would you describe your computer skills? (can ask specific questions: programming, PowerPoint, databases)
- Have you used computers for instruction before? How?
- Do you think that faculty members, in their teaching roles will rely more on computers in the future? (if yes then ask following 2 questions, if no ask the 3rd question)
- What specific roles might computers play?
- Do you think that the increased reliance on computer in teaching will tax the time/resources of faculty?
- Why do you think computers will fail to achieve more educational roles?
- How do you think existing computer systems can be modified to better serve you?
- How much time did you spend learning to use KM?
- Did using knowledge map increase or decrease your workload?

Information needs

- What information do you need to optimize your role as 1st year medical faculty? (e.g. current research in your specialty, student feedback, …) "what would you always like to know"
- How do you currently obtain the information you need?
- (probe if computers are among sources mentioned)
- How do you envision an ideal situation where computers fulfill your information needs?
- Did KM provide any of your information needs? (if yes, "How?")
    - (if no) Do you think it has the potential to provide for your information needs?
- Other than the topics covered in class, what are the information that 1st year medical students need to obtain? (e.g. clinical applications of basic science course?)
- What knowledge sources should be available to them in order to meet those needs? (e.g. literature search, real patient cases, etc…)

"Integrated" curriculum

- How relevant, in your opinion, is what you are teaching to other sections of the medical curriculum?
    - (if relevant) How do you think the current 1st year students will review your course content in the future?
- Do you think that 1st year medical students could benefit, while preparing for your class, from having access to course material covered in more senior years?
- Would YOU benefit from having access to other course material in the medical curriculum?

- How important to you is placing what you are teaching in context with respect to the medical curriculum? (e.g. clinical applications of your topic) {I have mixed feelings about this question – seems to be leading them to an answer}
- What in your opinion would be benefits of having the contents of the entire medical curriculum pooled in one application?

KM and Instruction in the medical school

- Did you attempt to search in KM for relevant documents to your lecture?
- Do you think that the knowledge about similar lectures to yours in the medical curriculum might alter the content of your lecture?
- Did the knowledge that your lectures will be analyzed for concepts and made available for searching, affect your choice of terminology?
- Did KM affect the way your handouts/slides were prepared (e.g. less graphics for faster downloads?)
- What concerns would you have from your lectures/ documents being available for the entire medical school?
- What feedback did you get from students about KM?
- Did you perceive any effect of KM on instruction? (e.g. do you have reason to believe that students may show up less to class now that lectures are available online)
- Do you have any concerns for the students stemming from KM? (e.g. inability to access documents when needed)
- What were your expectations of KM before you started using it?
- After the course was over, do you think they were met?
- Any other thoughts about your experience with KM?

APPENDIX F

STUDENT INTERVIEW COMPLETE NOTES:

General Information:

As mentioned earlier, 11 students replied positively to our email invitation. Scheduling constraints prevented us from meeting one of the students, and forced us to lump two students in one interview. The interviews took place in Light Hall, in reserved classrooms, and lunch was provided. Each of the nine interviews lasted between 30 and 50 minutes. The overall interview time with students was approximately 6 hours, generating 86 pages of transcripts (1½ line spacing, 12 point font). 3 of the students were female and 7 were males. The text was coded as described in the methods section.

To respect student privacy, they will be referred to by the aliases Students (1-10). Student 7 and Student 6 were interviewed together.

The topics covered within the interviews were grouped in two major headings: “The KnowledgeMap Application”, and “Learning with KnowledgeMap”. The former covers discussions on topics that relate to their usage of KnowledgeMap. Under the latter we will report how students viewed KM as pertaining to their learning experience.

The KnowledgeMap Application

Usage

When asked about their usage of KM, only one person, Student 4, reported never using KM. In fact Student 4 is the lone student who, from log file analysis, had never logged-on to the system until after the study was over. He had one encounter with the system, when one member of his study group logged on to the system. They were logged off in the middle of a presentation which meant that they had to retrace their work. They then decided not to pursue KM in that session. Another student, Student 9, said that he did not use KM much for anatomy. Although he appreciated the fact that slides presented topics in the same order as that covered in class, he concluded that most of images on the slides were taken from the Netter™ Atlas. So he decided to rely on the source directly. All the other students reported frequent and regular use of KM.

All the students reported that their primary use of KM was to check the class schedule and browse the related handouts and presentations. To them, KM was a way to review the lectures. Although some students (5) reported using it on a daily basis after attending the lecture, all (9) reported that their revision of lectures, through KM, increased in frequency in the last few days leading to an exam. Typically, students would convene in study groups prior to exams and would review the slides either in a class room (using available computers and projectors) or a library study room (using a checked-out laptop). None of the students reported utilizing the search capability as a typical use of KM. *However, all, including Student 4, anticipated that this capability will be valuable in their clinical clerkship years.*

(8) students, including Student 9, said that they would like to see KM applied across the board in all their courses. “I don't think you can get lectures from physiology or other classes. For me I would rather that it would be a uniform thing so that I can depend on it at all time. Because I know that we will have to get back to it when we're on the ward, and I will remember a lecture but can't get my hands on it.” (Student 6)

Although the adoption rate of KM was high among the subjects, their experiences with KM varied significantly. In the following sections we will present this heterogeneity along different axes.

Usability, Technical Problems and Satisfaction

All the students who used KM reported no problems in learning how to use and navigate KM. KM was "very self explanatory… definitely easy to use" (Student 5). Student 9's remark perhaps sums it up: "I think most people our generation… know how to use things like that".

One of the three people who reported on the survey that they were dissatisfied with KM happened to be among our interviewees. When asked about issues she had with KM, Student 3, who scored a perfect 7 on the Test Anxiety Score, reported that the system breaking down the last night prior to the exam was the most prominent. "It's just that it shut down as soon as you need it, and that's probably due to the volume… I don't know. I'm assuming it's due to the volume which is frustrating… that right when you need it, it shuts down!" She continued that she would also have liked to have the PowerPoint slides available before the lectures so she can see what she's going to learn. She then said "But I do like it. I think it's very helpful, and I don't know how I would get through without it."

Student 3 was not the only one to voice dissatisfaction from the system melting down on the eve of the second exam. Student 6, Student 7, Student 5, Student 2 and Student 9 made similar comments. Student 5 complained that the system was too slow sometimes. Another widely reported technical grievance is the inflexibility of PowerPoint presentations when viewed in HTML format. (Refer to survey results in last chapter). (6) students mentioned it as annoyingly lacking in KM. Student 1 went as far as saying that he felt he had to "unlearn" his PowerPoint skills to be able to cope with viewing PowerPoint slides on KM. In addition, this is the reason why Student 4 and his study group abandoned their KM session in the instance mentioned above.

Computer Skills

The students we interviewed had a slightly higher computer proficiency score than the rest of the students, but the difference was non-significant. (2.44 vs. 2.34; $p=0.5$) Student 5 had worked earlier as a computer consultant. Student 10 majored as a computer science student in the past. Student 9 reports having good "general computer skills" and had done work in computational quantum chemistry. Student 8 describes himself as an "advanced general user" and has recently programmed a mathematical model for physiology simulation. Student 1 held a computer-related research job, and recently acquired a laptop that he uses "a lot to study". Student 3 has web development skills and considers herself as having a "decent background compared to others" in her class. Student 7, Student 6, Student 2, and Student 4 said they have enough skills to get what they "need" from a computer but not exceeding that of the "average student". (Owned a computer, use Microsoft products, email, web searching, etc…)

Attitudes Towards Computers

"I think class room discussion is important, and I don't think its is necessarily good to always be increasing the amount of time we spend in front of a computer monitor. So I'm pretty comfortable with the degree to which computers have evolved in our daily lives at school right now." (Student 4)

The topic of computers in medical education was discussed with students and different points were raised with somewhat divergent views. Most students viewed computers as decreasing their workload. Furthermore, some of them – Student 3, Student 7, and Student 6 – pointed to the fact that computers increase the scope of accessible information and hence may place the students in a position where they are expected to know more. However, they still saw an overall increase in efficiency. When asked about KM in specific, only Student 4 reversed his position and said that had he and his friends pursued using KM further, their workload would have been increased. Student 9 and Student 5 thought that computers are irrelevant to discussion of workload, "I don't think the professors expected any more work. I would say that students do whatever, use whatever... I think if PowerPoint's weren't available students would have just studied the note, and the textbook. Now that the PowerPoint's are available, students will use the PowerPoint slides *and* the notes *and* the textbooks. That's just the nature of the medical students [laughs]" (Student 9)

All students interviewed regarded computers as valuable means of obtaining scientific information. Student 3, who went to graduate school before joining VMS, had extensive computer-based literature searches. Student 10 and Student 2 both mentioned that they use computers to track lay medical knowledge as well. For example, the recent media attention to a heart transplant-related death has prompted Student 2 to search for the relevant science behind organ rejection.

Student 6 and Student 9 both lauded the "consistency" in delivering information to all students that stems from having the lecture slides and notes available online. Student 4 and Student 2 praised the efficiency of communicating through email with both faculty and classmates. (7) students referred to a sense of *freedom and mobility* that is awarded through use of computers in education, e.g. accessing clinically relevant information from terminals on the wards in the future. Student 4 particularly made a remark on the potential usefulness of KM on the wards. Student 10 liked the fact that he can go through the lectures online if he's out of town.

On a similar note, Student 1 remarked: "I think for me, they wouldn't really replace lectures. In some schools, students have laptops that they use everywhere even in class. I think that's an overkill. Too much. There is a certain kind of learning that you have to do where you actually move your hand and write something and draw something, but I think ideally the usefulness would be: anywhere you are, you can get your computer up and online. Everything that's made available in class is made available online."

Student 2 cautioned that as computers will be become integrated in medical education, there may not be a "level playing field" for different student who come from different computer proficiency backgrounds. "I think that if it were gonna proceed in a direction where everything is computer based and we had some sort of standardized training would be nice, because there's differences between what I could obtain from a computer, just because I'm not very knowledgeable in computer use, and someone who has a background in computer science for example."

When asked if they keep a computer close to them when they study, (1) student – Student 4 – said that he absolutely turns his machine off when he studies, "because for me a computer is quite often a distraction. I tend to check my email and surf the web. For me when I'm studying, a low tech environment is better… just the paper in front of me." (4) students disagreed and said that they almost always have a computer close by when they study, however one of them – Student 9 – prefers to keep it a few steps away. "I'm one of those people who if I have a computers right off my hands. I'd check my email probably every… 5 minutes… and then go to the news every other 5 minutes."

In addition to Student 9 and Student 4, Student 3 and Student 5 reported seeing computers as potential distractions from studying. Student 5 was too distracted by online gaming that at one point he was about to give up high-speed internet access, and decided against that because of KM.

Pressure to Acquire Technology

"I didn't come here with a computer and I think that really *really* hurt my first semester performance because I was so dependant upon coming to these computer rooms, and you know people talk and, you know, that is where I'd have to study." (Student 3)

Students were asked whether they felt pressured to acquire technology by the adoption of KM. As per her quote above, Student 3 felt she was hurt by not having a computer, and added that she was buying one the week after the interview. Student 1, was "sort of sick" of coming to the computer rooms and using the projector, and acquired a laptop after the anatomy course was over, as well as high-speed internet access. He said that he didn't feel pressured, but that he bought a laptop as a personal choice. Student 6 felt that the computer access in school was sufficient and decided to *stop* her internet access at home. Student 2 said he *liked* to acquire a laptop but doesn't feel pressured nor the need to do so. He saw having limited access to checked-out laptops from the library around exam time as an inconvenience. Student 7, Student 5, Student 8, Student 9 and Student 4 had already a computer at home with high-speed internet access, and described KM as a 'bonus'. Student 4's comment on the subject was that he had "anticipated the need for a computer with high-speed internet access" before he joined VMS. He was glad he had high-speed internet access although he didn't "think it is necessary nor essential".

Suggestions and Future Visions

The most common suggestions by the students were to make the application more reliable, add more links to relevant resources from the online material, and adding more courses and lectures online. Many students envisioned smarter searching engines for biomedical information in the future.

Student 3 wanted to see links from the lectures to the literature and to illustrative case examples, to make KM more reliable (less server down time), to have physiology simulation resources, and to have more courses online. Student 10 envisioned computers' role in education to remain as a means and not becoming an end in itself. He hoped that various resources would become consolidated with easier accessibility. He wanted to see links from the online lectures to illustrative cases, to the literature and he thinks that all non-electronic lectures should have at least an electronic summary posted on KM.

Student 1 wanted more links and cross-references between the material. "Seems to me that the greatest advantage of having things online is to be able to link them and be able to see all the things that are related. Right now I know KM is trying to incorporate that into medical education… but right now that's not the way it is. There aren't any slides online where you see 'this is an example of such and such' or 'to read more about this, click here' [….] that would be really nice. Ideally, I'd love to see that.". He also wanted 3D simulations and video models. He envisioned better search engines for biomedicine in the future.

Student 4 envisioned that in the future computers will "anticipate our needs" and spare us having to worry about gory technical details. Student 2 wanted computers to become faster, more reliable, and with easier interfaces on search engines. Student 5 asked for more speed and reliability, and suggested that links to de-identified illustrative case examples be available on the online lectures. Student 7 and Student 6 asked for more classes and lectures to be online and for links that tie lectures to illustrative case examples. Student 9 wanted to have wireless access to a multitude of resources through a Pocket PC. He expects that search technology will encompass linguistics in a way that "would allow you to interact with computers more like a person, you know, not having to figure out what Boolean search you need to put in to make it work right".

Student 8 said: "One of the things that impressed me about Vanderbilt initially was that compared to some of the other places I was looking, the computing and informatics was of higher caliber and more dependable." He asked for a histology image bank, a comprehensive database of pharmacology, and for an electronic medical glossary to be tied to KM. He envisioned universal interconnectedness and smarter search engines that span multiple disciplines. "We're certainly not there yet, but I think that's sort of the idea behind it. That say you look up Left Anterior Descending artery and you get the anatomy slides that are showing you where it comes from and what it does… all the innervations… you get the physiology… and the pathology… All coming up at the same time. And that's always at the fingertips. That'd be ideal, … just the implementation of that… that's what I would like to see." He parted lines from the rest of the students when he said that he expected that users would become more savvy when it comes to using search engines rather than efforts being spent on making the engines themselves more friendly. This also extends to how he envisions knowledge acquisition by physicians: "There's more information out there, and as medicine will continue to progress… in a way there will be accumulation of vast amounts of knowledge that anymore, to rely on the memory of physicians will be something that gradually decreases, but having access to that information and knowing how to access that information and the information being there is going to be increasingly important. As physicians will be more of *skilled operators* than just *holders of knowledge*."

Learning with Knowledge Map.

KM and How They Study

Students where asked whether KM has affected their class attendance. 4 out of the 10 students replied that it did or probably did decrease their class attendance. However, some of the statements they made revealed that this is not merely a dichotomous opinion. Student 10 and Student 1 had different answers to the question, yet they made similar remarks: "I wouldn't say it affected my attendance... but if I didn't attend, it would make me more effective at catching up and mastering the material." (Student 10). "I think, for me, it made the overall course a lot better and helped me enjoy the course a lot more. I didn't get frustrated if I missed something in the lectures or if I had to miss a lecture it wasn't such a life and death situation." (Student 1). Student 7, Student 6 and Student 8 all made similar comments that KM provided a safety net in terms of being in class to take notes. Student 1 who thought that computers "wouldn't really replace lectures", further elaborated on this topic by saying "certainly there were lecture that I felt would be pretty boring, and the slides where gonna be online and I can go thru them on my own. But I also totally go to class right now, I figure I can learn from those quicker and more efficiently (by attending). [...] I sort of broke it down into classes where I felt I needed to go and classes where I didn't feel I needed to go. Embroylogy classes I felt where so confusing that I had to learn on my own... to be... functional with vocabulary before I can even look at concepts. So for that, I would use the KM slides, take time to go thru it and then look up the terms and know what they're talking about exactly."

Student 3 said that she would "feel guilty" if she didn't go to class and that attending lectures "helps to know what the professor emphasizes". Student 10 said he preferred to go to class because jokes, anecdotes, and even teachers' "mannerisms" and "facial expressions" help him retain the information presented.

Student 2 and Student 5, who both said that KM may have decreased their attendance, said that complete notes being handed out – regardless of whether they were online or in print – is what affects their attendance especially if professors did little more than just read their notes in class. "If I sit in class, I feel its an hour wasted when I can get the same information online when I need it. [...] I think my note taking is affected more by them handing out the notes. With very little we have to find out as additional information. Everything is either in the notes or on the powerpoint presentation. I find that with some professors it's a little different, but with a lot of professor they are reading lecture notes that they handed out. The information presented is almost identical." (Student 2)

When asked what they *felt* about attendance in general being affected by KM, almost all students had an ambivalent response. Except for Student 4, who vehemently asserted the importance of classroom discussion, ALL other students thought that it was mostly a matter of "personal choice" and "learning style". Student 2 and Student 1 said that there's "something to be said about just sitting in front of someone and listen to them explain things to you". Student 10 summed his opinion up as follows: "the question is, do the students learn it better?" (referring to some students not showing up when complete lecture notes are provided). "Because if you put the notes out there, and the powerpoints and all that, and the students don't come to class, maybe this is not what you think is the best teaching style... but the students learn it, and they learn it better or as good. Isn't that the ultimate goal? ... of school?! … IF we achieve the goal, does it matter so much if we don't do it that particular way? Because the students will... if they learn better by coming to class, they will come to class... and if they don't show up in class, then that's probably because they're learning it better studying at home."

The interviews touched on other topics that relate to how KM affects how students study. For example, there was general consensus on that having complete notes available relieves a lot of classroom pressure. "I think about taking these classes without taking these lecture notes, already prepared online. I can't imagine taking the notes, like writing, at all. I think that things are heading more towards that. [...] You can get your hands on it if you want in class or if you don't understand it you can go back and look at it." (Student 6)

According to Student 8, the fact that the lecture slides are available has the advantage of being a "useful tool for reinforcement." "I think it helped focus the work I did. Having access all the time to the actual, little, material covered in class, I thought was very useful, and helped, actually, decrease the amount of unnecessary work that I did. Because I knew that way I could determine... this is exactly what was covered, this is exactly the context in which it was covered. And so I don't need to be worried right now about these other peripherally related components of anatomy."

In lecture slides, pictures are clearly associated with the text of the notes. “Having the pictures is very helpful instead of having to look through three books and cross compare.” (Student 3) “I use it a lot when professors post up answers after we work through problem sets or post corrections to lectures. A lot of times teachers take slides from books we don't have so I look at pictures [...] rather than buying, like, 10 books for each class.” (Student 6)

All but Student 4, reported using KM to go through the lecture as preparation for their exams. The students did that in different contexts and at different stages of their preparation. However most reported using it in the last days leading to the exam. “When the exam was coming, a couple of weeks before the exam, I would stay after class. Either coming to one of these rooms or go to Eskind, checking a laptop and looking at the slides online. Pulling those up, having my atlases in front of me and going through all the slides online. [...] I'll go back and look through my notes again, and any ones where I find something confusing I go back and pull up the slides online again, look and go through that again. And usually from experience, I found that when you go back to them again, I start seeing more and more connections, and the way things really work.” (Student 1)

Similar to Student 1, most students mentioned that it was common practice for their classmates to convene in study groups and go over lecture slides online. This was commonly done in two settings: in classrooms in Light Hall where they would go through the lecture slides on the big projectors, or in Library study rooms using a laptop.

KM and how they learn

KnowledgeMap may affect how study habits, class attendance or even the physical location of where students study. But this does not necessarily imply that their learning of medical knowledge is also affected. As seen earlier the, the question of “how medical students learn?” is too complex and has been studied extensively by experts; however, are there specific elements of medical education that could be affected by KnowledgeMap?

Is it safe to assume that medical students, like other professional students, are more experienced learners? i.e. Do they have a higher level of metacognitive self-regulation? (Appendix C). The quantitative survey characterized the students by their metacognitive self-regulation scores, but it does not provide any comparison with other types of students. We tried to identify portions of the interviews that reveal the students’ “monitoring, planning, and regulatory” processes that make up metacognitive self-regulation:

- Student 10 tries to seek out “stories” behind every concept because he knows that to him, things “stick better” if they’re associated with a story. He is aware of the didactic mostly factual mode of instruction of the first two years of medical school and tries to adapt to it. “I think that at this point in time. Since my patient contact is limited and possibly also there's so much didactic learning going on... maybe that's best. But I don't try to have patient contact in order to facilitate the learning, but I welcome the opportunity.”
- Student 9 identified the difference between a “doctor’s” frame of reference and the “anatomist’s” frame of reference. He said that he maybe retained less than half of what he was tested on in the anatomy course (the interview was conducted 1 month after the course was over). “I think you try to walk away with the big picture perspective and hope that, you know... [pause]... the reality is, once you decide what your specialty will be, then you learn a lot of details for that specialty but you obviously can't know all the details of all specialties.”
- “I used to concentrate on the notes initially to get them memorized, as we were lecturing I just drew everything, I drew arteries, I drew muscles. I would add arteries as we went... By the end of it I would have my own picture that I've drawn and on a test I would remember it more than atlas pictures.” (Student 6)
- “I changed my strategy a lot. Originally it was just reading my notes,... and rephrasing those notes into my own version of how I thought the relationships went... [...] and I didn't spend much time in the lab to do the lab stuff...and then I went into making flash cards from the notes.” (Student 7)
- Both Student 8 and Student 1 recited in detail their study strategies: “First thing I would do is I would sit down with the notes and atlas in hand, usually Netter. [...] And I would go through all the structures that were labeled. I would locate them on the slides... so I knew where they were at now... I would take into account every single thing... after that was done, with all the lectures. I would go the sort of real life atlas of actual dissection [...] and would go through the slides corresponding to lectures and notes and stuff like that. And in the final week leading up to the exam I would spend a lot of my time in a room like this, going through lectures, often with another person. We would discuss all the slides that came up, the relationships between what is in the notes and what is on

the slides, and how that relates to the anatomy being studied as a whole. And try to synthesize." (Student 8) "[I] get what I could out of the lecture, just write down some things [over the notes].... And when the exam was coming, a couple of weeks before the exam, I would stay after class. […] looking at the slides online. Pulling those up, having my atlases in front of me and going through all the slides online. I tried to condense a few key concepts, or things that I felt were important for memorization... certain structures, like the brachial plexus or the lumbar plexus. A lot of times, of how they come together, usually try to draw these out by hand and have a quick reference you can pull." (Student 1)

Some of the strategies above (Student 6, Student 7, Student 8, Student 1) are instances of "elaboration". Elaboration strategies help students store information into long-term memory by building internal connections between items to be learned. Elaboration strategies include paraphrasing, summarizing, creating analogies, and generative note-taking. Do the students usually try to build internal connections within what they have learned so far?

- "To be quite honest with you, the information just doesn't stick if I don't contextualize it. For instance, once again, we were having an immunology exam the other day and we were looking at different diseases of immune cell development. We were looking at different t-cell and b-cell development diseases and what have you. And just trying to memorize the diseases by themselves, just wouldn't work. I looked at trying to memorize it like 5 times, and every time I came back to it, I didn't know it. But when I try to describe them in terms of my knowledge about t-cell... split them up and then see which ones apply to t-cell development... then... I was able then to memorize them and get them." (Student 10)
- Both Student 3 and Student 8 build hypothetical scenarios of how things might go wrong. "I would try to find clinical correlations. "What would happen if this went wrong". Which off course you could do on the web very easily. What I would mainly do is figure out what would have happened if whatever I was studying went wrong, and how you would then fix it." (Student 3) "I play it by games. Like what happens if this function is disrupted? sort of a hypothetical clinical situation. Not necessarily identifying, disease by disease: 'this is what happens'. But sort of I guess trying to make

up scenarios on my own and trying to figure out the results of dysfunctions. That helps me synthesize and figure out and understand it and things like that." (Student 8)

Sometimes, due to the nature and format of the course, it is difficult to reach an integration of topics.

- "I remember the lymph, you know, the lymph nodes. […] They put two sentences about the lymph in each lecture, so if you just look at one it doesn't make any sense. I remember trying to go through them with a friend and we were confused because there were 10 or so lectures, and each had a sentence or 2 of lymph somewhere in them, and then trying to tie it all together was just a mess we didn't know anything about it." (Student 2)

Building internal connections extends beyond a single course.

- "For instance, I was looking at the heart, and the SA node and trying to look at how the sympathetic system affects it. And kind of important to that is knowing what neurotransmitters are affected and what the biochemistry behind the mechanisms are. So I had to go back and review that. And also, I was trying to think of "where exactly IS the SA node?" kind of think about where the possible atrial connections between the SA node and the AV node. So I went back to Netter's and tried to picture it in my mind." (Physiology, Biochemistry and Anatomy – Student 10)

Integrating knowledge beyond one course becomes more evident as medical students become closer to their clinical years. The basic science courses are not gradations of specialization in related topics as is the case in graduate education, but rather courses with a fixed degree of specialization drawn from different disciplines. How important is it for students to understand the overall relevance of the covered topics?

- Some of them do consider it important: "I tend to be a practical person... when I study I focus more on stuff that seem more relevant for my future practice." "In general, if something is relevant, its easier for me to learn, I think. Because its easier to visualize... for example, histology. There are all these types of epithelium and glands and all that stuff. I focus on the features that cover damage of these structures. Because I don't really care about like... what... it looks like exactly." (Student 5) "I think a lot of the times here we're learning just for the sake of learning, that we kinda forget that we're gonna be doctors... we're learning just to get a grade whereas I think that having some kind of person reminding us that we have a bigger goal than just getting the grade, I think that would help a lot." (Student 7) "I think that we learn soooo much and like, I don't know about you, but I feel that 80% of it I forgot. But a clinical correlation where I remember that patient coming and talking about their disease, sticks in my head much much longer than the notes on that disease." (Student 6)

Perceiving elaboration, contextualization or relevance as helpful learning strategies may not necessarily imply that students use them. The medical school environment imposes a different reality on students.

- When asked whether she tries to correlate lectures and topics together, Student 3 said "No. [laughs] I probably should have, but, no, I was trying to memorize the individual lectures. I never got to that point." She added, "I try to associate it with things I would use in the future. However, I think that that doesn't really help you in your performance. If anything it would be somewhat harmful cause you won't be memorizing the detailed notes if you were thinking of more general concepts. And I think that wouldn't have been helpful. I did that, but I think it wasn't a good idea." Student 3, as mentioned before, has used KM extensively, was one of the three 'dissatisfied' users and scored a perfect 7 on the test anxiety score. She made multiple references throughout the interview to the workload on medical students such as: "I think we're expected that we do it all [laugh]... even if its not doable [laugh]" and "there is so much emphasis on the little tiny details that you only have 18 hours a day to study [laugh]." Some of other students made similar comments.

Limitations on time, and the large number of topics covered, force some of the students to rely on "blatant memorization" (Student 2) rather than the aforementioned strategies that foster long term retention.

- "I try to (connect concepts), but I'm also too conscious not to get too sidetracked. I try to... if I think of something which reminds me of something that I pretty well know where it is then I kind of make that connection. But if I'm not real sure about it, and there's no one to ask, I just move on because I don't want to waste the time confusing myself and looking thru piles of notes trying to find something that may not be important." (Student 1)

Sometimes the students think that it's in their better interest to ignore trying to learn the big picture or clinical relevance, and narrow their scope to the courses at hand.

- "I'm one of those who think that trying to solve problems in the 1st two months of medical school and trying to figure out all things that make up that problem and trying to solve it... is not a good idea. I'd rather have the base knowledge, or at least begin to learn it and be able to talk about it, and then... as far as I understand, in second year you begin to get some of these problems, and start to use that knowledge and bring it together to... sort of a more cohesive whole. To solve more problems, to understand more diseases: Why certain drugs or disease behave in a certain ways. For me that sounds like a very reasonable, a very logical way to learn things because trying to put them... trying to learn them in context and link to a bunch of other things that you don't know anyway just makes each individual concept more confusing and not less because it's referenced to something that I don't know." He later added, "its too easy to get lost. There's a really good quote: "everyone's two questions away from being an idiot"... and so at this point its 2 very simple questions for me. Before I start solving problems, I would like to get to the point where its 2 really good questions." (Student 1)

A question we asked the students assumed that there is a dichotomy in one's approach to learning medicine, trying to be a "successful doctor", i.e. taking the time to integrate knowledge into a big picture, versus being a "successful student" i.e. focusing on the minute details of the courses as needed for the exams. The students were asked which of the two they would chose:

- Four students chose the latter: "Now, I concentrate more on being a successful medical student. I didn't do as well on the first semester as I would have liked, and I'm doing much better this semester because I'm just... I think "who cares about the future" I'm just gonna memorize these detailed notes today." (Student 3) "Right now, the best way I see of going about to be a successful doctor is to be a successful student." (Student 4) "The latter [laughs]...Its just the nature of the beast here. I think the reality is that you have to memorize for these tests a lot more details than you'll ever remember when it comes time for the wards." (Student 9) "Where I'm at right now, I'm just trying to get enough information in my head so that I can get a B on an exam. That's basically all I think about. I don't think of the higher purpose of studying, or organizing across different topics and tying things together. I'm basically just trying to get by. We have a lot of information and I feel, this semester we have tests on minutia.... Not really minutia but its just that the volume of memorization that I'm primarily concerned with." (Student 2)

- Two students (Student 7, Student 8) answered that they would choose the former.

The remaining four students' answers indicate that they don't view the situation as a mere dichotomy as our question suggests.

- "I think I'm fully satisfied if the exam is gonna be on stuff that I need to know as a doctor. And my goal for right now is to learn what I need to know for this next exam. But to know it well, not just learn it to get by through the exams, but to learn it well enough so that I can remember some of it a little down the road. But I also realize that you have to see the stuff 8 or 9 times before you really know how to use it. And this is just really the first pass. So try to learn as much of it now, and do it later, and do it again and again..." (Student 1) "[laugh] that's a tough choice. I think that if studying for long term prevented me from getting a good grade, then I would study it short term and study it long term for the boards." (Student 10) "You learn a lot in 2 years [...] and I know they say that you forget most of it. They say that when you see the disease for the first time on a ward you never forget it, but I don't want to forget it, like, until then." (Student 6) "Hard question... I think... I think they should have a more practical approach to our quizzes. Rather than just try to memorize the details to ace the exams, even though that works... in Vanderbilt [laughs]" (Student 5), and then he went on to discuss problem-based and traditional curricula.

At this point, it can be concluded that most of the students did see the value in learning strategies that foster long term retention; however, the reality of the medical school imposes a situation where many students sacrifice these strategies in exchange for short term retention approaches to cope with the condensed nature of their coursework. Could KnowledgeMap help reverse that? KnowledgeMap provides an easy, and comprehensive retrieval of course materials with electronic searching capability. Wouldn't the ability to retrieve relevant concepts facilitate 'elaboration' or 'seeking relevance'? e.g. by reducing the time cost of searching through "piles of notes" or by simply making available upper year materials that students did not have access to before KM. We looked at some of what the students said when we discussed searching in KM:

- “Say for example you want to lookup dyspnea. In terms of our physiology course right now, it's relatively irrelevant. But say like a KM search on dyspnea could come up with hits on third and fourth year information that could be very useful to relating it back... just for the overall synthesis of knowledge... just relating to real life situations and understanding... that'd be a big kind of app.” (Student 8)

None of the students mentioned relying on KM for such a purpose. Some have never done any searches, while others did limited searches in specific situations.

- “To me its basically a resource that just put classes available online. I guess it could have some links to sites that are of interest. Maybe some ties to stuff that are clinically relevant. But now its basically lectures and powerpoint stuff... at least what I've used it.” “I think that what I'm more concerned when I go on KM is to find information that is directly related to my upcoming exam, and since the 3rd and 4th year curriculum won't be on my physiology exam on Thursday then I'm really not interested in it when I'm on KM.” (Student 2)

There was unanimous consent on the potential value of KM in the future for retrospective searches, e.g. bringing up basic science lectures online when they’ll get to the wards.

- “I don't think I will be able to find my biochemistry notes in third and fourth years. But if it were on a computer, that will be much easier. Especially if I could remember it being in one week, or one section... thinking I would be trying to find... even if there was a keyword search - or something - within the notes, I can still find that section” (Student 6)

In contrast, however, most did not see much value in doing prospective searches as part of their routine learning. We asked the students whether they would like to have access to upper years course material. These are some of their responses:

- “Yea! If I thought that they were easily accessible and if somehow I would know that that was there. I would find it helpful, I don't know if I would actually do it... because... I think it's a great idea and I think it would be helpful in the big picture. But just that there is so much emphasis on the little tiny details that you only have 18 hours a day to study [laugh]... I don't know how much I would use it but I think I would enjoy it if I could use it and I think it would be helpful.” (Student 3)

- "I think it would be necessary for us if there was a good interface for us to know and to highlight, at certain points, what information in senior class is relevant for us. [...] Not knowing the information in the senior class. I'm not able to go into that information and pull up something of relevance, as a freshman. But if that information were directed, and at certain points, they were to say... "this is of relevance." [...] irrelevant information may be distracting... it might be interesting, but it wouldn't improve my efficiency." (Student 10)
- "I think in certain circumstances... YES... The only think I would be wary of... I would say yes it would be beneficial... the only thing that would prevent me from doing this is the front-end work that I would have to put in to go and find out exactly what lecture and topics are being covered in the clinical clerkships. But if I knew that and I knew that it was something relevant to what I was studying, I would definitely go and look it." (Student 8)

Student 10 and Student 8 were both weary of irrelevant information misleading them down non-fruitful paths. Other students had similar concerns. A common theme that emerged was that information from upper year medical students could be curated by their professor and presented to them through a medium like KM as part of their curriculum.

- "It would be nice to be able to see why what we're learning is useful. [...] One is thing, the professors could maybe do on KM is make a list of primary sources that you could click on and read the articles so you would know what's accurate and relevant and what they want you to get out of it. Maybe just have a clinical correlation or an example of a patient with a problem with their knee when we're studying joints or something. That maybe linked to the hospital." (Student 3)
- "I think that probably the most useful thing that I think I would like to have access to, to help me learn the information other than what is taught in classes... is topics... lets say that are in the lecture notes or slide... if they were supplemented by (1) a link to either case examples or (2) to relevant research articles. Because there's a lot of information out there that they don't necessarily teach. Like we just did here in histology yesterday. There's a lot of things on how hair develops and stuff... I've been hearing about DHT, this hormone... and I would be interested in finding more about that because it would help, you know, hair growth cycle... and that would stick in my

memory. And when I went out there and found out articles about stuff, that may not come up in class, or not in depth... And that would certainly help interest, which would serve retention." (Student 10). Student 10 differed from other students, however, by cautioning that basic science professors are generally not medical doctors, which may undermine their ability to determine the truly relevant clinical material. He thinks MD's should supervise that.

- Student 7 and Student 6 talked about the merits of case presentations-type learning. When asked whether they think KM could provide that. Student 7 answered "no not the way it looks right now". Student 6 added, "I would say yes, but then it's a question of whether you had time to use it. Even its there I don't know if I have time to... I think it would have to be very integrated with the classes' curriculum." They were then asked whether they would like to have the ability to look up handouts and material from upper years, Student 7 replied "I don't know... I feel... I don't know what the materials from upper year classes would be." Student 6 then said, "[This learning] could be useful [to us] based on how much we know. Because I feel we don't know that much yet about treatment or diseases. Its all later in our curriculum, we're laying the groundwork for it. SO it would depend on information that is presented in that case that we would be able to understand." Student 7 added, "I was thinking about this when I was talking to other people. We were like "you know, this is such a great idea." If only we had a faculty member there that was more knowledgeable than us, that could provide us with extra information that would help make it... that would help us integrate it better and make it more real. Because I remember in our ecology of medicine class, our preceptor was a neonatologist and she was bringing in stories of what was going on, and I think that made it more real. And I remember thinking 'wow that stuff IS useful!'"
- "I think they do a good job of bringing in relevant diseases or relevant clinical correlations but I certainly, and this is going back to computers...it certainly would be nice if they know of a web page that has a nice description of a disease that's related, that they could put a quick link in there and stuff like that." (Student 9)

Finally, Student 1's remarks on hypermedia, its potential, and the need to fully exploit it:

- "Then the more things that are linked, like cross referenced... kinda like little links embedded inside of them. There's definitely not any of that... very little in the online tools. Seems to me that the greatest advantage of having things online is to be able to link them and be able to see all the things that are related. Right now I know KM is trying to incorporate that into medical education... but right now that's not the way it is. There aren't any slides online where you see 'this is an example of such and such' or 'to read more about this, click here' [....] that would be really nice. Ideally, I'd love to see that" (Student 1)

APPENDIX G

FACULTY INTERVIEW COMPLETE NOTES:

General Overview

Six faculty members were teaching the anatomy class during the study period. Their usage of KM consisted of uploading their lecture material (slides, handouts, notes) and assigning these materials to their respective class sessions. They also had the ability to view all online courses and lectures throughout the curriculum. Dr. Daley was the course director. He had the most extensive usage of the system, as he was in charge of entering the course calendar and assigning lecture to their respective instructors. He was given "course director" privileges on the system meaning that he had complete authorization over the electronic management of the course online. The other instructors were given "faculty" privileges, which restrict upload and session editing capabilities to their respective class sessions.

The other faculty were:

- Drs. Halle and Greenhouse: Both have primary academic appointments in Belmont University. They were interviewed in their offices in Belmont.
- Dr. Pettepher: At time of the interview she was course director of the histology course during the spring semester. The histology course was also using KM, so she had also experienced KM as a "course director".
- Drs. Nanney and Lambert: Used KM as instructors in both anatomy and histology.

This section will be divided into two parts, "The KnowledgeMap Application" and "Teaching with KM". Under the former we will report on discussions that relate to their usage of KnowledgeMap. Under the latter we will report on portions of the interviews that discussed medical instruction and how it may have been affected by KM.

The KnowledgeMap Application:

Usage:

All interviewed faculty had used KM. Their usage of the system was restricted to course management. Three faculty members had used the search capability to a limited extent within the anatomy course. Although they appreciated the potential value of search across the curriculum to their teaching roles, none had done that by the time of the interview. They used their own personal computers over the web and did not need any extra equipment or facilities to be able to access KM. One professor lauded the ability to upload her presentations from home. One professor speculated that a large number of students are using KM based on his personal observation of students in the computer lab. More than one professor remarked that it was common for them to be asked by students about the online availability of their lectures. One professor even named a champion student-user that had used KM extensively and suggested we contact him for interview.

Usability, Technical Problems and Satisfaction:

All professors said the system was intuitive and user friendly. "You guys were... just the fact... I think it's the level of your computer background. Once again... I'm not... I hadn't grown up with it... I didn't have a computer when I was 3. Its not a natural language for me or anything like that, but I could definitely pick it up if someone shows me. And its pretty much self explanatory if you know anything about computers. If anything, just go to the 'search' option or the 'browse' option and see what's available. So it worked out pretty well for me."

Dr. Pettepher appreciated the fact that one could just "drop things" onto KM as opposed to the more complicated problems she faces with another histology website that she maintains. Three professors said that it was helpful that the KM team showed up at an anatomy faculty meeting and went over the application with them before the beginning of classes.

One faculty member had a problem where a presentation that he had uploaded and which was, for technical reasons, was not available for students: "for some reason uploading files where I would upload them and I could see them on the KM but nobody else could? And when students would email me saying "hey its not up there", and you go "yes it is". That was definitely an issue, but hopefully that's been resolved. But that was really frustrating." Drs. Halle and Greathouse had problems initially in obtaining vunetid's (because they were primarily Belmont Faculty), and this delayed their participation in the system in the first few weeks of the course. The faculty knew that the system was down at a critical time before the 2nd exam and were concerned that that may have affected the students.

There was a lag time during the anatomy course between the time that lectures were uploaded and the time that they were made available to the students. The faculty had repeatedly expressed frustration during the course at that, however by the time of the interview this issue had been resolved by automating the indexing process. “I actually thought is was great, I really liked the ability to upload my presentations very quickly. I'm glad that this time, in the spring semester, and i'm not sure this was available in the fall semester, things got added really quickly. Within 5-30 minutes. Whereas anatomy, there was a down time and i think that that was very beneficial in that we could see right away that it was up and we didn't have to worry where in the realm of being uploaded is our presentation so that we could tell the students that it was on there.”

A corollary to this problem was the problem that making changes to an existing document was inflexible. “I was giving the skin lecture and I said hydrophobic instead of hydrophilic. And the students raised their hands saying did you mean hydrophobic or hydrophilic. And I had it written wrong on the [slides and on the handouts]... I just had it reversed. But it was just one slide, and just one error, but it's a pivotal error, you know. And it bothered me that I could have gone right back and changed it. [...] It's a small error, and I corrected it in class, and if they were there they would have heard it!”

The overall volume of emails that concern technical support during the class was 169 emails. More than 100 of those were communications between the KM team and the professors. The following is an excerpt from an email sent to us by one of the professors:

“I have received some complaints from students about not having access to our Power Point presentations immediately after they are given. That is one of the problems with today’s technology. While last year’s student had no access, this year’s students are upset because they don’t have instant access!”

None of the professors showed overall dissatisfaction with the system. Most of the issues arising were related to technical problems above. Issues relating to its impact on their instruction will be discussed in the next section.

“I haven't detected anything bad about the KM. I don't think it has affected the grades, we had the best grades this year we've ever had. Since Dr. Dalley's been here, since we've been doing PowerPoint and lots of visual images. SO the grades were the best they've ever been. I think that's a good thing. It gives us the chance to put more radiographs in here and try to mesh it more with other courses and things like that.”

The professors were asked how they perceived student feedback was. All said it was generally positive except for server downtime and the time lag issue. “We didn't have really that much feedback from the students. The only feedback that we really had was "hey I can't pull up your lecture". Which is great, I mean you'd love to have that feedback because then you know there's a problem and then you got to address that problem."

Computer Skills and Attitudes:

All professors reported moderate to advanced computer skills. Dr. Dalley is a champion of computer aided instruction in his field. When we interviewed him he was working on authoring an interactive anatomy atlas. It was thanks to him that anatomy was chosen as the pilot course for this study. Other professors reported that hundreds of hours of preparation may have gone into his powerpoint presentations which he uses to create elaborate and sophisticated animations to illustrate complex anatomical concepts for his students. Drs. Lambert and Pettepher have both directly maintained websites for their courses. Dr Nanney has extensive expertise in image processing software that she employs for her research. All professors reported proficiency and reliance on internet searches both for didactic and research purposes.

As for the future aspirations and visions, Dr. Pettepher expressed a need for an image base where normal and abnormal specimen pictures could be stored and shared across the curriculum. This comprehensive image base would bypass the need to obtain copyrighted images from books. Dr. Halle envisioned that computers would reach more interoperability making interfaces with humans friendlier and less concerned with details.

Teaching with KnowledgeMap

Teaching and Student Relationship:

Did KnowledgeMap change the way anatomy was taught? First we'll start with concrete effects. Dr. Greathouse noticed an increase in student email questions to him. More and more students send him specific questions on his slides. The first day that the KM team met with the anatomy faculty (prior to beginning of class), the subject of class attendance was raised as a potential concern. The concern was raised based on prior experience with co-op note-taking in embryology lectures, which ended up drastically decreasing class attendance.

"Yes I think it will affect class attendance.", said Dr. Nanney. She was then asked if whether she thought that that was a good thing or a bad thing. "I think it's a bad thing not to participate. Because when I give a lecture that's available on KM, when I give the live lecture, its not verbatim. Its not a video. [And I say additional things] that I don't cram on the slides. I have other points that I make, and they don't get that. I don't read my outlines. I try to follow it. Makes the students sad, but I don't read it. I think they want it on KM so that they don't have to come at all and just use that. Why teach? I can answer questions in the lectures and be more dynamic. See if the point is coming across. I like to teach, and its has taken the spontaneity of teaching. And I see that as a bad thing, because I have been teaching for so long. Some people are just comfortable with reading points: "bullet point one, bullet point two..." I'm not gonna teach that way. I have had trouble keeping my style of teaching in sync with the regimented slides and what's expected. I really don't like that."

Dr. Lambert, agreed with that concern. "I think attendance would be one thing I'd bring up. You know, you worry if they have everything already then why show?". "But," he added "that's also an issue that the educator needs to have with himself. If they're not presenting the information in a way that's stimulating the knowledge acquisition by the students, then they're not effective in what they're doing. So something needs to change. It might be a good thing."

Dr. Lambert saw decreasing attendance as part of a bigger loss of interaction that may result from something like KM. "I think KM would cut down on student interactions because a lot of times... in the past they didn't have access to your lecture. You gave it out there, if they have questions they would come and ask you. But now that we can upload our objective, our lecture notes, and our audiovisual presentations onto a remote location that they can access with a password. I think that actually cuts out on interaction and whether or not that's a good thing would depend... to whom you're speaking. Like I think that's a bad thing because I like the student interactions, others would love it because they don't want to be bothered by questions all the time."

They were concerned about student attendance, but did they actually perceive decreasing attendance? "I haven't detected, any negative effects. We're still having students come to class pretty much. When we used to have the old exams available, I would see negative effects from that. Because they would not study the notes, they would not listen to the lecture, and they would just study the old exams." (Nanney) "I don't think there has been a decrease in attendance. But I don't have any objective way to tell you that, just have a subjective feeling that I don't think there's been a decrease. Now, could that be a problem in the future? I think if you don't have people who are good lecturers that may be a problem. If they're really dry or something. Somebody could go and have the notes and have the powerpoints." (Greathouse)

Throughout the interviews the professors seemed to agree on the existence of a strain between making one's lectures interesting and attractive to avoid attendance drain, and between handing out and sticking to complete notes that cover the entire topics discussed in class:

- "I definitely realize that they have schedules that change and vary depending on their other course load, and I realize they may miss things. But the unfortunate thing is: when you emphasize something and then test them on it, and then people who didn't show up to lectures criticize you on the evals. Say "hey this wasn't in the notes!" [...] and you get that a lot." (Lambert) "Unfortunately medical student nowadays... and this is big problem... medical students are very grade oriented. And they're very much... they're NOT "wow its amazing how much information I've learned this semester. This is really going to help me treat patients in the future."... They're like "MAN I made an 89. That's horrible! Why did this happen? It's because this ONE person didn't give a good lecture." ... you know... so I think they loose track of the big picture."
- "I think what's expected from the students view point is that they're reassured and comforted when I just follow my outline, and the slide totally correlates with that, and is verbatim. If throw in a spontaneous fact that I didn't put in my handout, because somebody is asking a question, and I respond to it, or just think [incomprehensible]. I'm just spontaneously teaching about the topic... They don't like that. They don't like anything that's not written down already, because it might be on the exam. So I've changed my teaching style, and I'm not happy with it, but the constraint of it... [pause] I used to make the lectures different every year on purpose so they would have to come to the lecture." (Nanney)
- "I think if you just rely on what somebody gives you in a lecture, that's not enough for medicine. In an hour or an hour and half of lecture you can't cover everything you need to cover. And it doesn't mean that necessarily you need to go to the textbook. You need to go some other reference. [...] If anybody wants to look them up. But I'm not sure they do. But you know... med students all they want... they want the way to be best prepared to take the exam in the amount of time they have to spend studying one subject. So if they're gonna go with one thing, they'll go to the notes." (Greathouse)

Dr. Pettepher abstracted this strain to being the educational question of whether teaching should pursue active learning strategies (handing out pictures in histology) or guided controlled 'spoon-feeding' outlines that protect the students from being overwhelmed:

- "I would like to think that if I sit up there and give my talk... I don't know if my talk was different on a particular subject from last year to this year, however, what information I gave the students written down and typed up for them WAS different. Its like they want a written verbose handout of exactly everything that I say. Whereas they can get the majority of the information out of the textbook. I may have a different plan on how I present it or show different images, but if they came to my lecture jotted down some notes, and compare it to what they read, then they would have enough information. But also like in the past, because we show a lot of images we handed out a powerpoint-slide-handout instead of a written-text-handout because its all image-based. If they can jot something down on the image, and go back to look at it, then they would remember what it the point that we were talking about. But there's been conflicting information on whether they want images or they want words. SO [...] its sort of hard to know. I would like them to be stimulated and motivated enough to say "hey I'm interested in that topic, I'm gonna go read about it and I'm gonna go look at all the (microscope) slides." On the other hand I think there are those students that are overwhelmed by the volume of the material and they feel more secure if they had a handout that tells them what they need to know... and so its kind of a balance. Its not that they're not motivated enough, its just that they may not be able to handle the load. [Pause] See I am concerned, because we give them all this stuff, COULD they go and look up CHF and find out all the information that they... would they KNOW how to do that? I mean the information is there, but because we are giving it to them we are not necessarily encouraging them to go to the library and... I mean... you know? Because if I have all of these things readily available to me I can't see why I would go to the library..." (Pettepher)

Dr. Nanney seems to favor the active learning approach calling for a shift from the rigid existing lecture-handout-slide paradigm.

- "I don't want to make a problem based curriculum. I want to add that as a facet of learning. Different students learn through different approaches. Some learn more in the laboratory, by touching, feeling, seeing, doing in 3D. They learn better... they don't learn by the auditory mechanisms as well - someone more visual and tactile. So I want to include different types of learning that would include everybody. And I think that the problem based learning is the kind of learning more suited for the clinical setting realm. The lecture format, and just sitting in front of the computer is not necessarily it. I think we need to be multidisciplinary or something. I would like to add that. I do feel like the need to add that to be comprehensive. In fact we're short changing students if we don't do a little bit more of that. Because our curriculum has become too much: lecture based, powerpoint, lecture note. Its gotten all too rigid."

So in this context, is there a value added by KM to students and/or faculty by providing access to a comprehensive, searchable medical curriculum?

- Dr. Pettepher described the benefit of providing relevance to seeming non-relevant (for clinical education) basic histology. "Obviously its very important for pathology, so for the immediate future and [needing to be able to identify normal tissue to learn what's abnormal]." "they'll go back to the those individual powerpoint presentations and bring them up, and I know that there are (second year) students who went back and revisited those. You know, if I mentioned something about them in passing, that they would go back and call them up." "It may be easier to see the pictures on the ppt presentation in the exact context in which it was given to them."
- Dr. Greathouse saw benefit to the student from basic and clinical professors doing curriculum searches. "I think that would be very beneficial. It would be interesting to see what kind of lectures and what information they get presented, for example, in orthopedics or in neurosurgery for me... or neurology. [...] just sort of to see what they're exposed to, because I really couldn't tell you. Because I'd have to sit in on the classes, and as much as I'd like to, I just don't have the chance to do that." "It will be nice, if nothing else, just to get on KnowledgeMap and just see some of the topics and see how in depth they [clinicians] go with it. And I think it would be interesting to them to be able to come in to the basic sciences and see what these kids get in anatomy. It will give them a little bit better perspective on where they should be, you know a year and a half before they get into that service. But if they're doing their anatomy right they should be building on... all the way through the curriculum. [...] we talked about anatomy... it should be the same for physiology or any other basic science. They won't be able to make that next step when

something is introduced in the clinical arena if they don't have their basic science to fall back on. That's my opinion."

- Both young and veteran faculty can improve their lectures by knowing what's being taught where in the curriculum: "I also want to be sure that I'm in sync with what's being said clinically. Make sure that its correct and clinically relevant and that I'm saying the right thing. When I first came as a new faculty, I was asked to give the skin lecture in pathology. I was horrified, because I couldn't find out what was... anybody else was teaching it? Who taught it? Who gave that lecture, and what and where to start? Because I had to start from ground one. And I didn't have anything to build on, and I was really insecure about it. I think, young faculty especially, need to know what's being taught in other courses. [...] Every year when I've got to give a lecture I think "I wonder what they're teaching in pathology?" and I've gone actually to a couple of pathology lectures. When I was able to find out when they were taught!! I didn't have a way to find out when they were taught! How did I know? I couldn't see the schedule, I'm not a medical student, I didn't have access to the 2nd year schedule. I really did have to do some work to find out when it was taught and who was teaching it. So if you're a new faculty, its hard to find out who's who and who's doing what. If you can just go to your computer, turn on the web and find out, that's wonderful!! You can go talk to that person! In gross anatomy, I think, WITHIN a course I think it's a really good thing, because one lecture builds on the next lecture. That's why we all try to attend everybody's lecture, so that we try and not overlap in a negative way."
- Dr. Lambert alluded to the value of the retrospective search: "Some of the browse options would be very powerful but only if the other courses step up and start putting on the information. They can't tie in the information if they're not there offcourse, so... Its one of those things where its great if they were saying 'now I'm a 4th yearer, back in my second year neuroanatomy... I really want to know about basal skull fractures. What are the signs and symptoms for that?' Then they go to their neuroanatomy notes and go 'oh yea they go to the ER and they have raccoon eyes!'. It would be nice that once all the information is out there, it would be a good reference for them."

Finally, when asked whether she had any more concerns stemming from KM, Dr. Pettepher, the histology course director said: "What I'm concerned about is that I still think its necessary for them in my course to be able to look in a microscope, know how to use a microscope, look into a slide and be able to identify tissues. Not everybody is going to be a pathologist but I still think they need to be able to that. My one concern about computers and having images and everything available is that those are the best ideal images, and those students aren't always looking at something that... in the real world they might see."

Faculty-Specific Considerations from KM:

Copyright issues: The web is a very fluid medium that is easily transferred and copied. With professors going out to seek multimedia resources to put in their presentations, they may encounter some copyright issues:

- "I guess I kind of made sure that nothing was taken out of context from a book. You know exactly. The images were credited and i made sure that whenever images were used, or special words were used that were used in a textbook that may not have been something that we normally would call something. Those were highlighted and we put parentheses and accredit them with appropriate credits. We were just concerned that... you know... a lot of times we write down things so that we remember them or present them in a clear and concise manner and they could direct quotes out of a book. We just want to give credit where credit was due, and I think we are all concerned what things might get shoved off of KM where people have access to things, through the web, that could have been given credit..." (Pettepher) "I have gotten these images from a whole variety of sources, and I have to give credit to every source that I've got on every page, but even then I don't have permission to use those pages that I've taken from the textbook and scanned, even for teaching purposes. I don't have permission to use that even if I cite which textbook and which page it came out of. You're supposed to get permission to use it. So it is a problem, the more people will have access to it, I'm concerned about stealing their stuff. Their editors, they want me to buy the book. One of us buys the book? We check the book out of the library, we scan it in, and we would have stolen their book without having to buy it. It's a problem, and I don't know how to deal with that! [...] Copyright issues are not solved! [...] If this is going to be a problem, I'm not going to do it! [laughs] This really concerns Dr. Dalley a lot too. Because he's a book editor, and he's writing a book, I scan it and I have the image. Problem." (Nanney)

The last point raises a related issue, the intellectual rights of faculty in this medium. Are faculty members concerned about their intellectual rights?

- “I don't think I do. I think Dr. Daley would have an issue. One of the things I like about this is, when we spend most of our time on the PowerPoint presentation. And I think that it is important if you spend, you know, an hour animating one particular slide that's very intricate, that somebody just doesn't take it and put into their presentation and say it's theirs. And that's something that we're working here among the staff. But before all the information was "our information" in a general term. But now that people are putting tons of times, we're starting to cite those people. For instance if I use one of Dr. Dalley's animated slides. We're starting to make an issue of actually putting his name on the slide. So I think he would have probably more an issue, because he does a lot of intricate things that maybe people would want to copy.” (Lambert)
- “umm... yes and no. I feel that I’ve put a lot of time and effort into my presentations, and i would like for that to be acknowledge whereas students, I think, because they wanted our notes and things like that didn't recognize all the time and effort that it took us... that we put in to make sure that those notes were thorough and correct. So I don't know that they always appreciate that and then they make comments about taking directly from books. Well, depending on your subject matter, anatomy and histology have not changed in so many years and so it’s very difficult to describe epithelium... other than what it is! And so u can read my handouts and you can read all the textbooks and all the anatomy books and they all say the same thing. And so I don't want it to be misconstrued that I’ve stolen or I took something when I worked very hard trying to bring several concepts in and around together. Because it’s surely not my intention. I'm not benefiting off of any of the handouts that I’ve given anybody, its just work that I’ve done to make sure that the point gets across correctly. So I’m not trying to steal other people's information and I don't want my information stolen.” (Pettepher)

What constitutes plagiarism in this context? When multiple professors are teaching the same course and swapping lectures over the years where does ownership start or end?

- “I guess that may raise a plagiarism issue on our side. In an ideal world I would probably change all of mine. If I have a lecture that Dr. Dalley gave last year, I will modify that lecture and try to improve it. Because everybody's work is a work in progress. Some of us have a more finished work than others but, you know, we have errors. We have worse than ideal things. […] I'll modify his. At what point it becomes mine? No longer his and becomes mine? And that's a question we need to sit down with the course... That why you brought it to a head? *Because of KM, we had to sit down and have a course meeting and decide "Who owns it?"*... I don't know! Because if I change it fifty percent, YEA I've changed it. If I just change it five percent and I put my name on it, and he's spent gazillion hours preparing it. It's not fair, I shouldn't pass it as mine! These are the new ethical questions that we need to wrestle with." (Nanney)

Other than concerns over intellectual rights, what concerns do faculty members have from having their work available for scrutiny by the entire medical school community?

- "A down side to that is that people maybe wouldn't recognize work and effort that you do put in. They may not recognize that you teach three courses. They may just think that you teach histology and that's it, they may not realize that I teach embryology and anatomy. […] Some things may get scrutinized and wanting to know how they do it, and clearly you may not do it as well as they do and you should... you know, in your annual review... it could be brought to your attention that you could be doing it like theirs because that IS readily available, and that could be a problem. Off course it could be a benefit because people also recognize your notes... what your contributions are." (Pettepher)
- "It takes quit a while to prepare a powerpoint presentation that I'm satisfied with. And the time constraints are considerable. And I'm not through with the ones I've designed. They're like... a... prototype and they need much improvement. You know, all just a work in progress. They're the beta version of the lecture actually! [Laughs]" "Every lecture I change every year. I try to improve them all. I don't have a single lecture in my arsenal, of around 30 lectures, that I consider a final product. That I'm really confident with... they're all a work in progress. I'm looking for a better image to teach this particular concept. So I want to update the images that are in the program. I want to add to what I have, and supplement it, and modify it, and tweak it, and improve it. I think the visual impact of the page itself could need some thought as well, the colors and the organization and the busy-ness of it. I think there's... the art of it, the science of it, the accuracy of it. There's lot of facets to it and I'm not pleased with any of the ones that I created. They were all created under the gun the night before and finished up in the wee hours of the night because I had to give the lecture the next day. They had some spelling errors in them; they have images that are not optimized. I canned them in as fast as I could. I got the image there and we got the lecture done. They're not what I

consider, publication format. And I really don't like having them out there! [Stressed last sentence] I'm a little uncomfortable with having less than quality work out there. Usually when I put out images, they're publication quality for the whole world to see. And these lectures are still a work in progress... so... [pause]" "I'm not a surgeon, if I'm talking about the surgical relevance of my lecture I may be... out of date. I need to check my facts. I'm not a 100% percent confident of my facts." (Nanney)

…what about fostering communication?

- "I know that there has been question in the past about lecturing on specific topics and students not thinking that they're important. And the lecturers... feeling kind of upset about that. Because, how do they know what's important and what's not important, and they're not in a position to tell us what we should be talking about. But I think that if there was more communication... if that could be done via the KM, figuring where have they heard about congestive heart failure and how many times... do I need to spend precious minutes talking about that when they should have already heard three times. I think that would be very beneficial for the faculty. There are some topic that need to be discussed several times because they are extremely important, and they need to be come at from different avenues or reinforced with somebody else. I know another complaint that's been out there is that some students don't like that several members from different departments talk about things differently and/or maybe mis-communicate the facts. And it would be helpful if we all are on the same page or in agreement of what we're saying. So that we reinforce what each person is talking about not really singling out one, and saying "that's not right, this is the way it really is" I think it would be helpful for too many people who are presenting as well... in a broader sense." (Pettepher)

Would KM increase the faculty's workload?

- "Well...[pause] probably so. Because, I imagine that we'll see that some individuals... You are always kind of pushed to do something just as good as somebody else does, or a little bit better. And I'm wondering whether there will be a specific format that we can all kind of punch into and everything will be the same. I think that you see classes are taught better in one way, format than another and may be forced to do things so that they meet the standards of what another class is giving. I know that notes are important. If notes aren't the way students like them, then they complain, so they always use the example of another class. And

> sometimes that format is not right for your particular class. So yes, I see this... We're going to be maybe... Some things I think are great, but I don't know that we all can pass things equivalent through this that would suit that particular subject matter. And sometime when we strive to make things the same is not always better." (Pettepher)

Did the knowledge that the lecture material was available and searchable online change the format or the vocabulary of the course materials? All professors replied negatively, because they are already providing complete lecture handouts and notes.

Finally, many professors brought up that it is increasingly essential, for an educator, to possess information technology skills. "For instance if one of my students is using an anatomical CD and they can't figure out a certain function, and I'm like "uhh... I'm computer illiterate I can't help you". That doesn't look too good. So you got to be held to the same level of responsibility that you're holding the students." "I think now, to make yourself more marketable as an educator, you really have to be involved with all these multimedia presentations." (Lambert)

"I'm sure that one thing is true: change. I mean I'm not the most computer literate person in the world, I know how to do what I need to do and not necessarily more than that, but being forced to do PowerPoint presentations when you've never had to do them before is a daunting task. And once you learn how to do a PowerPoint presentation is great but then learning how to animate them is another totally different thing. And so each year we try to do a lot of new things… to add on... and it could be a daunting task if you're not exposed to these kinds of things before." (Pettepher)

APPENDIX H

EXAMPLES OF TYPES OF EVALUATION STUDIES

Examples of Demonstration studies include the following system demonstrations. Volpe et al developed a tool to teach basic medical genetics which was evaluated using satisfaction and computer background surveys. Usage data were used eventually to help aid the development[118]. Fontaine et al [119] presented a CAI system. The system utilized a knowledge base structured in a rule network. Student, author, and pedagogical modules were available for students and faculty. The author and pedagogical modules use the rule network to create simulated cases and well defined teaching scenarios respectively. The student modules help students solve clinical cases by analyzing and critiquing their answers. Gray et al used interviews with staff and students to assess the needs and use of a "University Linked Practices" computer system that links general practice offices involved in medical education [120].

Media comparative studies compared different modes of instruction for educational outcome measures. Bankowitz et al measured the effect of a computer-assisted general-medicine diagnostic consultation service - the QMR knowledgebase - on housestaff diagnostic strategy. The residents filled in a questionnaire summarizing the impact of QMR on their management of 31 cases. QMR added a diagnosis to 14 cases, reordered diagnoses in 7 cases, and ruled out diagnoses in 8 cases. Overall, the residents rated the system as having positive educational value and a positive value with respect to management of cases [121]. Devit et al used pre- and post-test scores to assess three different approaches to presenting subject matter through CAI (anatomy and physiology of biliary tree). Identical scientific content was produced using three presentation styles: didactic and problem based approaches, as well as free text. Only the first group performed better than controls [122].

There exist evaluation studies on CAI in medicine where the study design and outcomes are not of the typical comparative media framework. Rawson et al mapped learning principles from the *How People Learn* Model[123] to a software that teaches acid/base physiology. Students who consented to the study filled evaluation questionnaires and pre- and post-tests that assessed their learning of the material. Some students were selected for in depth interviews. They found that the case-based format helped students construct their understanding of Acid/Base physiology, and stimulated debate among students who had different understandings. Repetition of concepts developed “a complex networks of understanding”, and the questions helped “scaffold” the learning process. Guidelines for further software development were generated based on their findings [124]. Steele et al designed a CAI module used in the third year clerkship in surgery that teaches technical aspects of angiography. Outcome measures included student completion of the Rezler Learning Preference Inventory (LPI), a computer attitudes survey, an evaluation questionnaire, and in-depth interviews. The LPI characterizes learning preferences as being abstract or concrete, individual or interpersonal, and student-structured or teacher-structured [125, 126]. There was no relationship between learning preferences, computer attitudes, and evaluation of the CAI program. Overall the students were satisfied with the system, although they voiced concerns that it may supplant student-teacher contact [127].

Anatomy:

Demonstration studies: ATLAS-plus [Advanced Tools for Learning Anatomical Structure] is a multimedia program used to assist in the teaching of anatomy at the University of Michigan Medical School. ATLAS-plus contains three courses: Histology, Embryology, and Gross Anatomy. In addition to the three courses, a glossary containing terms from the three courses is available. The program is a collaboration between anatomy and cell biology faculty, medical students, graphic artists, systems analysts, and instructional designers.[128] Radiologic Anatomy is a multimedia system that teaches radiology in an elective course for first year medical students at the University of Florida. The system provides for self-evaluation testing. [129]

Media comparative studies: Hallgren et al developed a web-based tool for learning anatomic landmarks. The users performed better than non-users on the midterm and final exams in the course. [130].

PBL-related systems: Levine et al used table-side computers in a gross anatomy lab to provide dissection instructions, images, online references, and quizzes. The student feedback from this system over 3 years guided the transition into problem-based instruction of the anatomy course[131].

APPENDIX I

PROBLEM BASED LEARNING AND PBL-CAI

Many medical schools in the 1980s and 1990s have undertaken reform in their curriculum to embrace "Problem Based Learning" PBL. PBL in medicine is an instructional method where real patient problems are used to learn (1) problem solving skills, and (2) acquire knowledge about the basic and clinical sciences. "The basic outline of the problem based learning process is: encountering the problem first, problem solving with clinical reasoning skills and identifying learning needs in an interactive process, self study, applying newly gained knowledge to the problem, and summarizing what has been learned."[132] The underlying assumption is that the problems encountered serve as motivation to identify and actively fill defects in knowledge. A conventional curriculum is one where there are 1-2 years of instruction in the disciplines that constitute what is called 'basic sciences'. The instruction is done through lecturer-centered presentations with periodic examinations. The knowledge is usually organized in taxonomies specific to these sciences rather than in a clinically oriented context. This is followed by 2 years of clinical clerkships where students are supervised as they perform patient care. It is in this stage that their knowledge base is applied to clinical problem solving. [133]

Many CAI interventions have been used to support PBL programs in medical schools. Carlile et al, presented the rationale for PBL adoption and described how information technology played key role in the PBL curriculum at University of Sydney. They used an intranet to coordinate the efforts of 400 faculty members to develop 72 medical problems used in the first two years of the medical school curriculum. Of note, a formative assessment system offered important real time feedback on the learning of the students [134]. Giani and Mortone developed a distance learning model grounded on the integration of PBL and the use of web tools. They used cognitive maps of knowledge, termed Dynamic Knowledge Networks, synchronous and asynchronous web based communication tools, and hypermedia to go beyond the mere presentation of didactic material and harness the active, engaging, collaborative, and student-centered learning process of PBL. They tested this model with a group of medical and nursing students and presented the DKN that was developed by that virtual classroom [135]. Rendas et al developed a computer simulation that walked the user through the information searched, the formulation of the working hypothesis and the identification of learning issues. Printouts of the system where analyzed to evaluate the 'progression profile' of the students. They observed that during the early phases the students identified 'gaps' in their previous knowledge about mechanisms and manifestations of the diseases in question, and that the greater specificity of the questionnaire found in subsequent phases was "related to the knowledge acquired during the self-learning period". [136] Mooney et al describes the development and structure of an Electronic Study Guide for Oncology (LETSGO) for undergraduate medical students. LETSGO was aimed at clinical students learning about cancer and designed to follow the steps used in problem-based learning. It utilized interactive features, and hyper-text links to core text and diagrams. The program was designed to provides dynamic access to the student's existing knowledge base and to stimulate new learning based on the student's own learning needs. [137]

Studies of educational outcomes failed to establish PBL as the better mode of instruction. In a review of PBL outcomes from the literature, Albanese and Mitchel found that compared with conventional instruction groups, students in the PBL group rated their learning environment as more nurturing and enjoyable and faculty members were highly satisfied teaching using PBL. Students in the PBL group performed equally well on clinical examinations and faculty ratings, but less well on basic sciences examinations. In addition, students in the PBL group viewed themselves as less well prepared in the basic sciences than were their conventionally trained counterparts [133]. In the same year, Vernon and Blake reported their meta-analysis of evaluative research on PBL. They found no differences between PBL and conventionally trained students in local tests of factual and clinical knowledge, but that PBL students scored higher on measures of clinical performance, whereas conventional instruction students scored higher on the National Board of Medical Examiners Part 1 Exam, taken after the first two years of medical school. The authors emphasize the heterogeneity of measures between programs and caution the generalizability of their finding [138]. A decade later, Colliver [139] reviewed the literature in the interim and concluded a lack of evidence of an effect of PBL on NBME examination scores, diagnostic reasoning or clinical skills. Furthermore, he expressed skepticism at its theoretical foundations and dismissed many constructs (such as 'activation of knowledge networks') as "nothing more than metaphor and demonstration, nothing that taps into the underlying substrate of learning that would allow prediction and control." He did, however, acknowledge <u>self-directed</u>

learning as an "important, but neglected, area of research that avoids this abstract cognitive speculation and gets directly at a valuable skill that is central to the PBL approach."

Researchers did acknowledge, however, the benefit of some of the learning strategies associated with PBL. Norman and Schmidt reviewed the evidence pertaining to the psychological basis of PBL. The authors sought published experimental results that validate claims made by proponents of PBL - claims mostly based on literature from psychology of learning. Based on their review they concluded that (1) there is no evidence that PBL curricula result in any improvement in general, content-free problem-solving skills; (2) learning in a PBL format may initially reduce levels of learning but may foster, over periods up to several years, increased retention of knowledge; (3) some preliminary evidence suggested that PBL curricula may enhance both transfer of concepts to new problems and integration of basic science concepts into clinical problems; (4) PBL enhances intrinsic interest in the subject matter; and (5) PBL appears to enhance self-directed learning skills, and this enhancement may be maintained[140]. Vimla Patel et al studied novice, intermediate and senior students in two medical schools with different curricular formats: Conventional and PBL. They were asked to give diagnostic explanations of clinical cases. A predominantly "backward-directed" hypothetico-deductive[7] mode of reasoning was found in the explanations of the PBLC students, and a "more forward-directed"[8] pattern of reasoning was found in the explanations of the conventional curriculum students. Students in the PBL curriculum produced extensive elaborations using relevant biomedical information, which was relatively absent from the CC students' explanations. However, these elaborations were accompanied by a tendency to generate error. [99]

Hmole, Gotterer, and Bransford examined two groups of medical students at Vanderbilt, one taking an elective in PBL and the other taking other electives. The students were asked to perform a pathophysiological explanation task. The researchers examined their problem solving strategies, proper use of scientific concepts, and self-directed learning. They were particularly interested in the effect of PBL on self-directed learning strategies and measured that effect by having students assess their learning needs and generate plans to address those needs. Their

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[7] A hypothesis is devised from which can be deduced certain explicit, observable predictions. These predictions are then put to empirical test.
[8] This is a reasoning strategy in which clinical data "triggers" the diagnostic hypothesis, i.e. "Pattern Recognition". Typically used by domain experts.

cognitive measures were able to distinguish the students in the PBL group from those in the other. Furthermore they were able to replicate Patel's work on directionality of reason. [141]

APPENDIX J

RESEARCH STRATEGY:

Research Design and Questions:

A media comparative design for evaluating KM was not chosen for various reasons. (1) an outcome study needs to be controlled for different dependant variables. At the current stage of knowledge, we do not know all factors that affect first year anatomy course performance. (MCAT scores? Undergraduate major? Undergraduate institution? GPA? etc..) (2) The number of students in a typical medical school class is in the order of one hundred. A study design controlling for such confounding factors not only segregates students into smaller "bins", but also decreases the total study participation due to the extra burden of collecting such private information. Thus the statistical power of the study diminishes. (3) The limitations of media comparative studies that are discussed in the background section.

Furthermore student outcomes in the anatomy course are not particularly pertinent to the goals of KM itself. Unlike, for example, an anatomy teaching software, KM is not tailored to improve instruction of a specific medical topic. There is face value to the medical school community in making the entire curriculum available and searchable, however that value is not as specific and unambiguous as improving student performance in one specific course.

Friedman and Wyatt discussed the evaluation process and how it relates to various stages of development of an information resource. The following is an excerpt from their book [83]:

> Evaluation is integral to information resource development, and adequate resources must be allocated for it when time and money are budgeted for a development effort. Evaluation cannot be left to the end of the project. However, it is also clear that the intensity of the evaluation effort should be closely matched to the resource's maturity. For example, one would not wish to conduct an expensive field trial of an information resource that is barely complete, is still in prototype form, may evolve considerably before taking its final shape […], or is so early in its development that it may fail because simple programming bugs have not been eliminated. Equally, once information resources are firmly established in clinical practice, it may take hard work to convince funding organizations that a rigorous evaluation is still necessary.

The following are the research questions for this evaluation study.

Q.1 What is the extent of use of this system among the students and faculty members in the course?

Who is using KM? What fraction of the medical students? How frequently are they using KM? What features of KM are being used the most? Are the users satisfied? Such questions are typically presented in a "demonstration study" and would entail collecting information about actual usage (web server) in addition to information from the users (survey: satisfaction, simple demographics). The study by McNulty et al has demonstrated the value of combining these two sources of information [111, 112]. As an interesting side topic, concordance between actual use and reported use of KM will be studies (As mentioned earlier, the McNulty study did indicate discordance between the two but it was not reported in the classical concordance analysis form).

Q.2 What factors could explain this usage pattern?

To answer this question, the users will be characterized by attributes that offer intuitive explanation to usage patterns. Such attributes will extend beyond simple demographics to include

Computer proficiency: To be collected through the survey.

Computer attitudes: To be collected through the survey.

More detailed usability issues: To be collected through the survey Students will be asked specific questions beyond general satisfaction level. Likert questions, where people indicate agreement or disagreement on a numerical scale, have been used to quantify a group's sentiment/opinion to specific statements. The specific questions would deal with technical errors, design preferences, reliability, and user friendliness.

Learning Strategies: Research in applied psychology offers a multitude of instruments – e.g. surveys – that can quantitatively measure psychological “constructs”[9]. In evaluating their CAI tool, Steele et al have used the Rezler Learning Preference Inventory, which characterizes learning preferences as being abstract or concrete, individual or interpersonal, and student-structured or teacher-structured [127]. Keeping in mind the learning strategies mentioned in the last section, we have elected to use the Motivated Strategies for Learning Questionnaire MSLQ [115, 116]. The MSLQ, a widely cited and readily available instrument, combines both motivational and learning strategies scales. The motivational scales are divided according to value components (intrinsic motivation, extrinsic motivation, and task value), expectancy components (control beliefs, self efficacy for learning), and affective components (test anxiety). The learning strategies scales are classified as cognitive and metacognitive strategies (rehearsal, elaboration, organization, critical thinking, metacognitive self regulation), and resource management strategies (time and study environment, effort regulation, peer learning, help seeking). Note that the importance of affective components other than “test anxiety” has been discussed in the literature. Pekrun et al [142] described a taxonomy of positive and negative emotions, that are experienced by students in academia. Delving further into this topic is beyond the scope of this research.

Issues not envisioned a priori: For that, we space leave space for free form expression of ideas in the survey. Furthermore, and as mentioned earlier, qualitative evaluation methodologies, e.g. ethnography, have been used to evaluate novel informatics systems. They do not rely upon a prior hypothesis. This will be discussed in the next chapter.

Q.3 How does KM affect medical instruction?

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[9] Construct - an attribute of an individual or a phenomenon that is not directly observable, but which is theoretically based or is inferred from empirical evidence. Examples include "intelligence," "anxiety," and "job satisfaction."

By medical instruction we mean the following four broad topics:

Students study habits: e.g. how, when, where, and with whom they study for anatomy; Note taking; Class attendance; technology requirements.

The way students learn: different experience with KM for students with different learning strategies.

Faculty-student interactions and lectures: classroom relations; Personal communications between faculty and students; lecture format and content; the effect of the knowledge that lectures will be viewed online on lecture format and style; the effect of knowledge that course material will be indexed for searching on the choice of terminology; concerns stemming from students relying on KM; professors' perceptions of the effects of KM on students.

Faculty specific considerations: faculty workload; faculty concerns from lecture being available online for entire medical school; pressures for adoption of technology; career advancement; positioning of individual faculty's work in the context of broad curriculum; KM fostering communication with other faculty in the medical school.

Qualitative Research Design:

Data to address the second and third question will be collected through qualitative research methods. Our design strategy will be that of a naturalistic inquiry which looks into real-world situation as they unfold naturally, is non-manipulative and non-controlling, and open to whatever unfolds [143]. Of the different theoretical traditions of such inquiry we will follow a positivist/realist approach, i.e. working under the presumption that there is a real world with verifiable patterns that can be observed and predicted. Other likely traditions: *ethnography*, *constructivism*, or *social constructionism* would have been considered had our investigation been centered on the organizational or collective impact of KM instead of the individual learning experiences. Although we should point out work [98, 135, 144, 145] that argues that social interaction is essential for the development of the knowledge networks. *Grounded theory*, relies on generation of theory through systematic comparisons, and constant testing in grounded fieldwork. The illusive nature of cyberspace, and the cognitive processes that accompany the use of KM, make such extensive grounded fieldwork untenable.

Our research will be an evaluation with both summative and formative components. The evaluation that will follow the Responsive/Illuminative Model, i.e. sensitive to the different perspectives of the stakeholders and requires face-to-face contact with people involved.

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