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LAW SCHOOLS AS KNOWLEDGE CENTERS IN THE DIGITAL AGE

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INTRODUCTION

Law schools address various societal needs, including educating new lawyers for the profession,[1] researching and critiquing the legal system, and helping to increase the fairness of legal decision-making and the access to justice for all members of society.[2] To these ends, law schools have focused on articulating the requirements, relevant communication techniques, and logical application of justice and fairness in society in order to educate new lawyers for professional participation in the legal system.[3] This process entails analyzing and critiquing legal rule systems and policy objectives. The digital age in the twenty-first century brings both complexity and opportunity to such traditional tasks. This article suggests that law schools have an opportunity to

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1. *See, e.g.*, WILLIAM M. SULLIVAN, ET AL., EDUCATING LAWYERS: PREPARATION FOR THE PROFESSION OF LAW 21-46 (2007).

2. *See, e.g.*, Thomas M. Mengler, *Celebrating the Multiple Missions of a Research I University-Based Law School*, 31 U. TOL. L. REV. 681, 684 (2000) (discussing the proper priorities on teaching, research, and service at law schools that are part of a research university); Rex R. Perschbacher, *The Public Responsibilities of a Public Law School*, 31 U. TOL. L. REV. 693 (2000) (discussing the missions of public law schools in terms of genuinely free access, a learning environment that prepares students for democratic leadership, engagement with public needs, and accountability); Mark Tushnet, *Research and the Justice Mission of Law Schools*, 40 CLEV. ST. L. REV. 463-67 (1992) (discussing the relationship between research in a law school and its justice mission).

The basic mission of Stanford Law School is probably typical:

[D]edication to the highest standards of excellence in legal scholarship and to the training of lawyers equipped diligently, imaginatively, and honorably to serve their clients and the public; to lead our profession; and to help solve the problems of our nation and our world. *History of Stanford Law School*, STANFORD LAW SCHOOL, http://www.law.stanford.edu/history (last visited Apr. 23, 2013).

3. Kirsten A. Dauphinais, *Valuing and Nurturing Multiple Intelligences in Legal Education: A Paradigm Shift*, 11 WASH. & LEE RACE & ETHIC ANC. L.J. 1, 3-15 (2005) (discussing Gardner's theory of multiple intelligences as it applies to law, including logical-mathematical intelligence and linguistic intelligence).

become digital "knowledge centers" for society as part of their central mission, and thereby accomplish many of their traditional goals through innovative digital means.

This article first defines the general concept of a "knowledge center," and then demonstrates that research laboratories in the sciences provide a concrete example of that concept. This article then applies both the general concept of a "knowledge center" and the scientific research paradigm to legal education in the digital age. Since the information explosion, which occurred as a result of widespread access to the Internet and the World Wide Web,[4] law schools have increasingly employed online tools to disseminate their traditional knowledge products. Being a knowledge center in the digital age, however, also involves re-conceptualizing the forms of useful knowledge and developing digital tools for accomplishing new tasks. The Research Laboratory for Law, Logic and Technology (LLT Lab) at the Maurice A. Deane School of Law at Hofstra University provides an extended example of the new opportunities and tools available to law schools. The LLT Lab, however, provides only a few specific examples of how innovative law schools could function as knowledge centers in the digital age.

I. THE CONCEPT OF A KNOWLEDGE CENTER

The societal roles of a knowledge center are numerous and interrelated. The general notion is that a knowledge center is an institution dedicated to solving real problems in society by developing, applying, evaluating and disseminating knowledge as a tool or instrument for problem solving. This part of the article summarizes the essential activities of a knowledge center. Subsequent parts supply numerous examples that illustrate each of these activities.

A knowledge center focuses on solving real problems in society. First and foremost, a knowledge center focuses on particular, unsolved problems in society, and develops the information, knowledge and conceptual tools for analyzing those problems and solving them

4. An estimated 2.4 billion people were Internet users as of June 30, 2012, or over 34% of the world's population. This constitutes an increase in users of 566.4% since 2000. *World Internet Users and Population Stats*, INTERNET WORLD STATS, http://www.internetworldstats.com/stats.htm (last visited Apr. 23, 2013). Nielsen reported in August 2010 that, "[d]espite the almost unlimited nature of what you can do on the web, 40 percent of U.S. online time is spent on just three activities – social networking, playing games and emailing . . . ." *What Americans Do Online: Social Media and Games Dominate Activity,* NIELSENWIRE, (Aug. 2, 2010), http://www.nielsen.com/us/en/newswire/2010/what-americans-do-online-social-media-and-games-dominate-activity.html.

effectively and efficiently. The target problems (and areas of knowledge) can be as varied as decreasing the prevalence and severity of health problems associated with childhood obesity (medicine, behavioral science, public health) or predicting the effects of climate change (geology, meteorology, economics). While merely preserving and transmitting knowledge that has been useful for problem solving in the past is an important function, a knowledge center does not merely preserve such knowledge; it also uses past approaches to problem solving as a foundation for developing new forms of knowledge needed to solve current and future problems.

A knowledge center evaluates knowledge effectiveness. Effectively solving real-world problems is the primary focal point of a knowledge center. Thus, a knowledge center evaluates the effectiveness of the knowledge that it develops, by empirically assessing the success or failure of using that knowledge to solve problems, and by continually testing alternative approaches to solving those problems.

A knowledge center re-conceptualizes knowledge processes and structures. When solving new problems requires not merely acquiring new information, but also developing and testing new forms of knowledge, a knowledge center conducts research on the processes through which knowledge is created, the structures used to represent and store knowledge, and the methods used to apply knowledge. Knowledge centers are always searching for more efficient and more effective processes, structures and methods. In doing so, it can be useful to distinguish "information" from "knowledge," so long as rigid definitions do not constrain innovative thinking. Information consists of statements, propositions or data contained either in unstructured documents (such as governmental reports, scientific publications, emails, or web pages) or in structured databases.[5] Knowledge, by contrast, grows out of insights or experiences about how to use information to successfully perform activities as varied as inferential reasoning, question answering, game playing or traveling into space.[6] In this sense, the

5. *See, e.g.*, *Information Management*, WIKIPEDIA, http://en.wikipedia.org/wiki/Information_management (last visited Apr. 23, 2013) (discussing the collection and management of information, and its distribution); JAMES GLEICK, THE INFORMATION: A HISTORY, A THEORY, A FLOOD 8 (2011) (calling information "what our world runs on: the blood and the fuel, the vital principle," and stating that "[i]t pervades the sciences from top to bottom, transforming every branch of knowledge").

6. *See, e.g.*, *Knowledge Management*, WIKIPEDIA, http://en.wikipedia.org/wiki/Knowledge_management (last visited Apr. 23, 2013) (discussing knowledge management as "a range of strategies and practices used in an organization to identify, create, represent, distribute, and enable adoption of insights and experiences").

difference between a novice and an expert is that the latter knows how to access, evaluate and use information in order to solve a problem successfully. While philosophers for millennia have debated whether possessing a warranting explanation is what converts a belief that happens to be true into knowledge,[7] researchers today are more likely to be reluctant to prescribe any particular definition or structure for knowledge.[8] In this article, "knowledge" will refer primarily to the expertise for solving problems using information.

A knowledge center disseminates and implements new knowledge. A knowledge center makes its insights and products available to society because the value of the knowledge that a center develops lies in its use, so that its work has a real effect upon society's problems and contributes to a cumulative evolution of human knowledge. Also, unless the application of the knowledge developed is studied, it is difficult to assess how effective the knowledge is at helping to solve real problems. Thus, dissemination, application, evaluation and development constitute an iterative process.

The next part of this article illustrates the activities of a knowledge center by discussing research laboratories in the sciences, particularly in the digital age. After that, the third part applies the concept of a knowledge center to law schools.

II. SCIENTIFIC RESEARCH LABORATORIES AS KNOWLEDGE CENTERS FOR SOCIETY IN THE DIGITAL AGE

Universities have traditionally functioned as knowledge centers for their societies by not only preserving and transmitting the knowledge of the past, but also by developing new forms of knowledge

7. Many philosophers since Plato have considered warrant as converting mere true belief into knowledge. *See, e.g.*, ALVIN PLANTINGA, WARRANT: THE CURRENT DEBATE 3-5 (1993); JOHN L. POLLOCK, CONTEMPORARY THEORIES OF KNOWLEDGE 7-10 (1986). This view, however, has engendered doubts from the very beginning. At the end of Plato's dialog *Theaetetus*, Socrates remarks: "So, Theaetetus, neither perception, nor true belief, nor the addition of an 'account' to true belief can be knowledge." To which Theaetetus responds, "Apparently not." FRANCIS M. CORNFORD, PLATO'S THEORY OF KNOWLEDGE 161 (1957) (translating Section 210a-B of the dialogue). *See also* KENNETH M. SAYRE, BELIEF AND KNOWLEDGE: MAPPING THE COGNITIVE LANDSCAPE 121-28 (1997) (attacking the notion that knowledge is a special subclass of beliefs).

8. *See, e.g.*, RONALD J. BRACHMAN & HECTOR J. LEVESQUE, KNOWLEDGE REPRESENTATION AND REASONING 1-15 (2004) (providing, instead of a definition of "knowledge," examples of "how we talk about it informally," and indicating that the authors will talk rather about "knowledge representation and reasoning"); STUART RUSSELL & PETER NORVIG, ARTIFICIAL INTELLIGENCE: A MODERN APPROACH 320-74, 462-91, 678-711 (2003) (discussing representing knowledge using ontologies, reasoning with incomplete information or uncertainty, and developing learning methods that take advantage of prior knowledge about the world).

needed to address new problems. Within modern universities, the research laboratories of the sciences furnish ideal examples of knowledge centers. The basic design of these laboratories has a few essential elements: faculty, students and staff working collaboratively to solve problems current in the society outside the laboratory; employing the scientific method to form hypotheses about possible solutions and to test the effectiveness of those hypothetical solutions; and funding the efforts of the laboratory through support from stakeholders (governmental, philanthropic, and private sector) who have an interest in effectively solving those problems. McKinsey & Company has concluded that the best research laboratories strategically target a portfolio of interconnected projects, with each project defined by the specific problem and solution sought, and with teams of researchers working collaboratively on solutions.[9] The training and education of new members occurs primarily through a problem-solving, collaborative process.[10] The Science Coalition, an organization of more than forty public and private research universities in the United States, states that universities conduct the majority of basic science research in the United States (55% in 2008).[11] The Science Coalition also states that the federal government provides some 60% of the funding,[12] and

9. For insight into particular features of those scientific research laboratories that are highly successful, *see* Mark Beards et al., *What Drives Research Productivity? An Understanding of How the World's Most Successful Laboratories Operate Reveals Some Answers*, PHARMA R&D COMPENDIUM (2009), *available at* https://solutions.mckinsey.com/successlab/_SiteNote/WWW/GetFile.aspx?uri=:/successlab/default/en-us/Files/wp1591276990/McKinsey-RAndD-Compendium-SuccessLab_e95a23ea-b486-4567-9584-9798afd06ad5.pdf (reporting the results of interviews with academic innovators and scientists, as well as the practices of research laboratories in industry and academia) [hereinafter *McKinsey Report*]. The McKinsey Report cited five elements of the approach of successful research laboratories: (1) strategic decisions (having "[c]lear, three- to five-year strategies, focused on portfolios of interconnected projects"); (2) talent management (in evaluating researchers, rating "intrinsic intellectual capability, scientific curiosity, and general problem-solving skills higher than specific technical knowledge"); (3) project and portfolio management (designing "their portfolios of projects to be interlinked, so that they are both additive . . . and synergistic," and assembling project teams "to incorporate the mix of skills needed to address particular problems"); (4) problem solving (defining "a project by the specific solution sought," formulating hypotheses, and using "a variety of approaches to solve the problems along the way"); and (5) collaboration (sharing culture, knowledge and difficulties within and among project teams, and utilizing external collaboration to "enable a wider group of researchers to be brought to bear on the biggest challenges").

10. *Id.* at 3 ("Existing team members are expected to commit significant time to the one-on-one apprenticeship of new joiners . . . and to assist in the continuous mentoring of junior lab members.").

11. *Sparking Economic Growth*, THE SCIENCE COALITION, 3 (Apr. 2010), http://www.sciencecoalition.org/successstories/fullReport.cfm.

12. *Id.* at 8.

it lists economic "success stories" (including Google, Inc.) that originated in federally funded, university-based research.[13]

One increasingly important area of scientific research in the information age is linguistics and information science. Empirical research in this area provides a useful example of a scientific research laboratory. For instance, the field of linguistics has undergone its own revolution in the digital age, spurred by the tremendous increase in research opportunities through the Internet. This revolution is particularly noteworthy in the areas of natural language processing (NLP) or computational linguistics. This research is converging with research in the information sciences, addressing such problems as search and document retrieval, information extraction, data mining, and semantic and predictive coding.[14] Universities such as Stanford, Carnegie Mellon, Columbia and New York University provide other examples, setting up scientific research laboratories to study problems associated with a wide range of activities, such as language translation (both written and oral), child language learning, language comprehension, and biomedical information extraction.[15]

Linguistics and information science research laboratories also provide a particularly useful example for creators of legal knowledge. The scientific study of language is an important counterpart to law,

13. *All Profiles*, THE SCIENCE COALITION, (Apr. 2012), http://www.sciencecoalition.org/successstories/index.cfm?keyword; *Research & Development, Innovation, and the Science and Engineering Workforce*, NATIONAL SCIENCE BOARD, 1, 9 (2012), http://www.nsf.gov/nsb/publications/2012/nsb1203.pdf. (in federal fiscal year 2009, the federal government provided 58% of the academic spending on research and development in the United States). As an example of a federal funding mechanism, the Experimental Program to Stimulate Competitive Research (EPSCoR) of the United States National Science Foundation (NSF), a program established in 1979, has as a major objective "to activate effective jurisdictional and regional collaborations among academic, government and private sector stakeholders that advance scientific research, promote innovation and provide multiple societal benefits." *About EPSCoR*, NATIONAL SCIENCE FOUNDATION, http://www.nsf.gov/od/oia/programs/epscor/about.jsp (last visited Apr. 23, 2013). The North Dakota EPSCoR, for example, has programs funded through federal-state-private sector partnerships. *North Dakota EPSCoR Programs*, NORTH DAKOTA EPSCOR, http://www.ndepscor.nodak.edu/programs/index.htm (last visited Apr. 23, 2013). The North Dakota EPSCoR has a comprehensive research development plan and has provided grants for research laboratories within North Dakota universities. *Research Groups Build Competitive Research Infrastructure for North Dakota*, NORTH DAKOTA EPSCOR, http://www.ndepscor.nodak.edu/frontiers/index.htm (last visited Apr. 23, 2013).

14. These activities are discussed *infra* pp. 887-900, 904-18.

15. *See, e.g.*, THE STANFORD NATURAL LANGUAGE PROCESSING GROUP, http://nlp.stanford.edu/ (last visited Apr. 23, 2013); NATURAL LANGUAGE PROCESSING/COMPUTATIONAL LINGUISTICS AT CARNEGIE MELLON UNIVERSITY, http://www.cs.cmu.edu/~nasmith/nlp-cl.html (last visited Apr. 23, 2013); NATURAL LANGUAGE PROCESSING AT COLUMBIA UNIVERSITY, http://www1.cs.columbia.edu/nlp/index.cgi (last visited Apr. 23, 2013); DEPARTMENT OF LINGUISTICS AT NEW YORK UNIVERSITY, http://linguistics.as.nyu.edu/page/home (last visited Apr. 23, 2013).

because legal rules, policies and decisions are expressed almost entirely in language, and the work products of lawyers (arguments, briefs, opinion letters, etc.) are essentially linguistic. Language is a critical means by which the rule of law brings about justice and fairness in society. In practice, both linguistics and law take the basic constraints of syntax and grammar as given; both attempt to interpret the meaning or semantics of linguistic expressions; and both generate hypotheses, arguments and evaluations about the pragmatic effects of linguistic structures. While linguistics and information science aim at a different set of objectives than law does, both linguistic research and legal research produce knowledge about language processes and structures. Thus, because the study of knowledge acquisition is central to much of the research in linguistics and the information sciences (as discussed later in this part of the article), they should be of particular interest to law schools as knowledge centers in the digital age.

The next four subsections of this part use the science of linguistics and information science to highlight scientific research laboratories as knowledge centers in the digital age. Linguistic and information research laboratories focus on solving real problems in society – problems that have become particularly important in the information age. They evaluate the effectiveness of their theories in solving those problems, which sometimes leads to re-conceptualizing their knowledge processes and structures. Finally, they disseminate and collaboratively implement the new knowledge that they develop. As an important by-product of their research, they train new generations of scientists, as faculty and students work together to solve societal problems. As a result, linguistics and information research provide a particularly appropriate example for law schools of scientific research in the digital age.

A. Scientific Research Focuses on Solving Real Problems

The scientific research laboratories of our universities target the real, unsolved problems of society. Moreover, their funding is roughly correlated with how well they help society address those problems.[16] Given that focus on helping to solve real problems, it is not surprising that scientific research laboratories at universities in the United States frequently partner with private commercial enterprises in mutually

16. *See supra* pp. 883-85.

beneficial research and development projects.[17] Each member of this partnership is adept at serving a specific purpose: research laboratories are able to study and develop the basic knowledge required to solve a problem, and private enterprises are able to transform the knowledge into practical applications and provide testing and assessment.[18] In addition, research and development are seen as integral drivers of economic growth and innovation, which explains the frequent financial involvement in academia-industry research projects by the federal government.[19] For example, the passing of the American Investment and Recovery Act of 2009 resulted in an increase of federally funded academia-industry research projects in energy, medical, and broadband research.[20] Although basic research programs by themselves often lack "direct commercial applications" and are therefore unattractive to financially motivated private enterprises, basic research "plays a critical role in sparking innovation," and often provides the knowledge that is translated into tangible products and drives productivity.[21]

In the digital age, empirical research in linguistics and information science provides a useful example of research laboratories partnering with government and the private sector to address societal problems.[22] One illustration is the series of Message Understanding Conferences (MUCs) in the late 1980s and the 1990s, sponsored in part by the

17. Jennifer A. Henderson & John J. Smith, *Academia, Industry and the Baye-Dole Act: An Implied Duty to Commercialize,* CTR. FOR INTEGRATION OF MED. & INNOVATIVE TECH. 1, 6 (Oct. 2002). For an example of the experimental collaboration between university research and real-world problem solving, *see* Ariel Kaminer, *New Cornell Technology School Will Foster Commerce Amid Education*, N.Y. TIMES, Jan. 22, 2013, at A22 ("Cornell NYC Tech, a new graduate school focusing on applied science, is a bold experiment on many fronts[,] . . . [b]ut the most striking departure of all may be the relationship it sets forth between university and industry, one in which commerce and education are not just compatible, they are also all but indistinguishable").

18. *See* Henderson & Smith, *supra* note 17, at 6.

19. *See Research & Development, Innovation, and the Science and Engineering Workforce*, NATIONAL SCIENCE BOARD (2012), http://www.nsf.gov/nsb/publications/2012/nsb1203.pdf; William F. Ferreira, *Academic-Industry Collaboration Under Federal Grants and Cooperative Agreements: Financial, Administrative, and Regulatory Compliance*, 18 RES. MGMT. REV. 1 (2011).

20. *Id.* at 2.

21. *The Pivotal Role of Government Investment in Basic Research*, U.S. CONGRESS JOINT ECONOMIC COMMITTEE (May 2010),
http://www.jec.senate.gov/public/?a=Files.Serve&File_id=29aac456-fce3-4d69-956f-4add06f111c1.

22. Two goals of the Text Analysis Conferences (TACs) organized by the National Institutes of Standards and Technology (NIST) are illustrative: "to increase communication among industry, academia, and government by creating an open forum for the exchange of research ideas" and "to speed the transfer of technology from research labs into commercial products." *Text Analysis Conference*, NIST, http://www.nist.gov/tac/about/index.html (last visited Apr. 23, 2013).

Defense Advanced Research Projects Agency (DARPA).[23] The MUCs focused on the problem of extracting information from unstructured texts.[24] For example, the MUC-3 task was to extract information on terrorist incidents from plain-text news articles.[25] The idea was to assemble teams of researchers that would design and implement a computer software system to perform the chosen task, and both universities and private-sector companies participated.[26] Thus, the MUC-3 task provides a good example of a real societal problem: identifying and extracting a particular kind of information from a large set of unstructured documents.[27] Jackson and Moulinier have concluded that the series of MUCs was extremely fruitful for a number of reasons, including that "[t]he emphasis on having a practical running system avoided the normal tendency of researchers to focus their eyes on the far horizon."[28] The goal was to produce genuine know-how with respect to actually solving a practical problem, and the MUC metrics for evaluating performance will be discussed in the next section of this article.

The Text Retrieval Conferences (TRECs) furnish another example of academic, governmental and private-sector collaboration to solve societal problems in the digital age by developing and testing new knowledge for retrieving relevant text from unstructured sources.[29]

23. PETER JACKSON & ISABELLE MOULINIER, NATURAL LANGUAGE PROCESSING FOR ONLINE APPLICATIONS: TEXT RETRIEVAL, EXTRACTION AND CATEGORIZATION 69-112 (2d rev. ed. 2007).

24. *Id.* at 70.

25. *Id.* at 71.

26. *Id.* at 70.

27. The relevance of this task to legal services should be clear – such as finding evidence for argumentation in litigation. *See infra* pp. 904-09, 919-21 (discussing computer-assisted legal argumentation and e-discovery). Of additional importance to legal services is the summarization task at the heart of a series of Document Understanding Conferences (DUCs) conducted by the National Institute of Standards and Technology (NIST) in the current century. *See* JACKSON & MOULINIER, *supra* note 23, at 208. For example, DUC 2007 had as a main task "to produce 250-word summaries of multiple documents in answer to a complex question." *Id.* "A typical task requires the [computational] system to take as input a DUC topic, plus a set of twenty or so relevant documents, and generate a fluent summary of 100 or 200 words that answers the question posed by the topic." *Id.* at 209.

28. *See* JACKSON & MOULINIER, *supra* note 23, at 70.

29. The TREC series was started in 1992, and has been co-sponsored by the National Institute of Standards and Technology (NIST) and the U.S. Department of Defense. *Overview*, TEXT RETRIEVAL CONFERENCE (TREC), http://trec.nist.gov/overview.html (last visited Apr. 23, 2013). The TREC workshop series has as goals (among others) "to increase communication among industry, academia, and government by creating an open forum for the exchange of research ideas" and "to speed the transfer of technology from research labs into commercial products." *Id.*

For discussions of TREC, *see generally* Maura R. Grossman & Gordon V. Cormack, *Technology-Assisted Review in E-Discovery Can Be More Effective and More Efficient Than Exhaustive Manual Review*, 17 RICH. J. OF L. & TECH. 11, 12 (2011); Jack G. Conrad, *E-Discovery Revisited: The Need for Artificial Intelligence Beyond Information Retrieval*, 18 ARTIFICIAL INTELLIGENCE & LAW 321

TREC workshops consist of sets of tasks known as "tracks," which focus on particular sub-problems or variants of the retrieval task.[30] An important example is the Legal Track of TREC 2011, for which the objective was "to identify as nearly as practicable all documents from a collection that are responsive to a request for production in civil litigation, while minimizing the number of unresponsive documents that are identified."[31] Teams originated from ten different organizations, including universities (e.g., University of Melbourne, University of South Florida, and University of Waterloo) and private-sector companies (e.g., Recommind and OpenText).[32] Performance results in this track will be discussed in the next section of this article.

A final example of research collaboration to solve societal problems is IBM's Watson program, which combined the capabilities of natural language processing, hypothesis generation and evaluation, and evidence-based machine learning into the Watson computer system in order to compete with human experts in the *Jeopardy!* game show.[33] *Jeopardy!* is a popular televised game show in which the player must respond to a clue (stated in the form of an answer) by supplying an answer in the form of a question (the question to which the clue is the correct answer).[34] The competition "requires answering rich natural language questions over a very broad domain of topics, with penalties for wrong answers."[35] In this particular Watson project, IBM

(2010); Douglas W. Oard et al., *Evaluation of Information Retrieval for E-discovery*, 18 ARTIFICIAL INTELLIGENCE & LAW 347 (2010).

30. TREC 2013 CALL FOR PARTICIPATION, http://trec.nist.gov/pubs/call2013.html (last visited Apr. 23, 2013).

31. Maura R. Grossman et al., *Overview of the TREC 2011 Legal Track*, THE TWENTIETH TEXT RETRIEVAL CONFERENCE (2011), http://trec.nist.gov/pubs/trec20/papers/LEGAL.OVERVIEW.2011.pdf; *see also* Oard et al., *supra* note 29, at 366-79 (discussing the TREC 2011 Legal Track); Conrad, *supra* note 29, at 331-33 (discussing the TREC 2011 Legal Track).

32. Grossman et al., *supra* note 31, at 2 (Table 1); *see also About Us*, RECOMMIND, http://www.recommind.com/company (last visited Apr. 23, 2013); *Company*, OPENTEXT http://www.opentext.com/2/global/company.htm (last visited Apr. 23, 2013).

33. D. Ferrucci et al., *Building Watson: An Overview of the DeepQA Project*, 31 AI MAGAZINE 59, 68 (Fall 2010) [hereinafter *Building Watson*]. On the Watson system, *see This is Watson*, 56:3/4 IBM J. RES. & DEV. (May/July 2012); M.C. McCord et al., *Deep parsing in Watson*, 56:3/4 IBM J. RES. & DEV. Paper 3 (May/July 2012); J. Fan et al., *Automatic Knowledge Extraction from Documents*, 56:3/4 IBM J. RES. & DEV. Paper 5 (May/July 2012); C. Wang et al., *Relation Extraction and Scoring in DeepQA*, 56:3/4 IBM J. RES. & DEV. Paper 9 (May/July 2012).

34. *Building Watson*, *supra* note 33, at 61.

35. *Id.* The clue may also contain puns or puzzles, such as:

> *Category*: Before and After Goes to the Movies
> *Clue*: Film of a typical day in the life of the Beatles, which includes running from blood thirsty zombie fans in a Romero classic.
> *Answer*: *A Hard Day's Night of the Living Dead*

collaborated with eight universities to develop an open architecture to advance the Question Answering (QA) technology behind the Watson system.[36] The Watson *Jeopardy!* application required the development of analytic capabilities "to understand what is being asked, analyze massive amounts of data, and provide the best answer based on the evidence it finds."[37] The developments in this suite of tasks (whose success in the competition will be discussed in the next section) are important contributions to problem solving in many areas, such as healthcare (medical diagnosis), banking, and government.[38]

This section has provided examples of how scientific research laboratories—and in particular, linguistic and information science research laboratories in the digital age—are focused on solving real problems in society, primarily by developing the basic knowledge that can help to solve those problems. This focus has made it natural for scientific research laboratories to partner with government and with the private sector in this effort. The next section discusses a natural byproduct of this combined effort: the development and application of metrics for evaluating performance when the new knowledge is applied to solving actual problems.

B. Scientific Research Evaluates Knowledge Effectiveness

The focus on solving real problems in society, together with a dedication to scientific methodology, requires scientific research to measure how well the ideas, hypotheses, and theories developed by researchers actually help to solve targeted problems. For example, in linguistics and information science, the performance metrics of "recall" and "precision" are standard means of evaluation.[39] When the subtask is information retrieval (e.g., identifying and retrieving relevant documents from a collection of relevant and irrelevant documents, or identifying and extracting relevant sentences from a document), *recall* is the proportion of the total number of relevant items that the system

Id. at 62.

36. *Id.* at 75.

37. *Id.*

38. *Id.* at 68.

39. *See, e.g.*, JACKSON & MOULINIER, *supra* note 23, at 45-48; DANIEL JURAFSKY & JAMES H. MARTIN, SPEECH AND LANGUAGE PROCESSING: AN INTRODUCTION TO NATURAL LANGUAGE PROCESSING, COMPUTATIONAL LINGUISTICS, AND SPEECH RECOGNITION 455-56 (2d ed. 2009).

retrieved.[40] *Precision* is the proportion of the total number of retrieved items that are relevant.[41] Recall is therefore a measure of retrieval effectiveness (the "hits ratio"), and precision is a measure of retrieval efficiency (the "signal-to-noise ratio").[42] In using any retrieval strategy, there will be a trade-off between recall and precision: a strategy that maximizes recall (e.g., by retrieving *all* items, and therefore 100% of the relevant items) would minimize precision, and a strategy that maximizes precision runs the risk of having very low recall. Any real-world strategy must target some balance in performance between recall and precision.[43]

Scientific researchers also collaborate to test the effectiveness of the ideas and techniques they develop. Jackson and Moulinier report that the MUCs were successful in part because each event provided "a uniform set of training and testing materials" and "encouraged rigorous evaluation using an agreed set of metrics."[44] With regard to recall and precision:

> The best MUC-3 systems reported results in the ballpark of 50% recall and 60% precision for event extraction. Roughly speaking, the programs could find about half of what they were looking for, with a false positive rate of less than 50%. By MUC-6, the best systems were scoring as high as 75% recall and 75% precision, where performance seems to have reached a plateau.[45]

MUC-6 introduced "Named Entity extraction" (NER) as a component task – i.e., the finding and extracting of proper names of people, companies, places, etc.[46] As Jackson and Moulinier note, whether 75% recall and 75% precision are satisfactory performance scores depends upon the application—an intelligence analyst searching online news reports might be quite satisfied with such performance, but a lawyer looking for legal precedents might not.[47] However, both the analyst

40. If *a* is the number of relevant items retrieved, then recall = *a* / n, where n is the total number of relevant items in the source collection. JACKSON & MOULINIER, *supra* note 23, at 46-47; JURAFSKY & MARTIN, *supra* note 39, at 455.

41. If *a* is the number of relevant items retrieved, then precision = *a* / m, where m is the total number of retrieved items. JACKSON & MOULINIER, *supra* note 23, at 46-47; JURAFSKY & MARTIN, *supra* note 39, at 455.

42. *See* JACKSON & MOULINIER, *supra* note 23, at 47.

43. There are also composite measures that can give different weights to recall and precision (depending on the objectives of the application), and that combine them into a single metric. *See, e.g.*, *id.* at 48; JURAFSKY & MARTIN, *supra* note 39, at 455.

44. JACKSON & MOULINIER, *supra* note 23, at 70.

45. *Id.* at 72.

46. *Id.* at 71.

and the lawyer might be satisfied with such performance in a screening tool, or as one search tool to be used along with others.

Grossman and Cormack, coordinators of the TREC 2009 Legal Track, report that the results of that TREC "show that technology-assisted processes can achieve high levels of recall and precision."[48] The document collection used for TREC 2009 consisted of 569,034 email messages and 278,757 attachments produced by Enron for the Federal Energy Regulation Commission.[49] One task was to retrieve from these documents any that related to the alteration or destruction of documents or other evidence.[50] The performance of one team (Team H5) on this task was estimated to have 76.2% recall of relevant messages and 84.4% precision.[51] When Grossman and Cormack compared the performance of two teams on five tasks with the performance of the TREC manual reviews, and computed the statistical significance of performance differences between team and manual reviews, they concluded that "by all measures, the average efficiency and effectiveness of the five technology-assisted reviews surpasses that of the five manual reviews."[52] In particular, for the task and Team H5 mentioned just above, the manual review had an estimated recall of only 36.9% (compared to Team H5's 76.2%) and an estimated precision of only 25.5% (compared to Team H5's 84.4%).[53] While interesting, what is important to this article is not whether technology-assisted document retrieval can out-perform purely manual retrieval, but rather the notion that scientific research laboratories place a high priority on evaluating the effectiveness of their developed know-how.

47. *Id.* at 72. Moreover, such metrics as recall and precision might not be adequate for evaluating performance on certain tasks. For example, in the DUCs conducted by NIST, one task was to produce a summary on a particular topic from a set of relevant documents. *See supra* note 27. Summaries, however, can be incoherent in ways not evaluated by recall and precision – for example, by assembling text fragments poorly or by including pronominal references that have no antecedents. JACKSON & MOULINIER, *supra* note 23, at 209. To adequately evaluate summaries, new metrics had to be devised. *See id.* at 209-10.

48. Grossman & Cormack, *supra* note 29, at 14.

49. Bruce Hedin et al., *Overview of the TREC 2009 Legal Track* 4-5, THE EIGHTEENTH TEXT RETRIEVAL CONFERENCE (NIST SPECIAL PUBLICATION: SP 500-278) 1, 5 (2009), http://trec.nist.gov/pubs/trec18/papers/LEGAL09.OVERVIEW.pdf.

50. *Id.* at 6.

51. *Id.* at 17 (Table 6). Due to the large number of documents in the collection that would have to be manually reviewed for relevance to create a gold standard against which to measure team performances, a stratified sample of 3,975 messages was reviewed to ultimately determine that 216 of those messages were relevant. *Id.* at 12, 38 (Tables 3 & 18). This resulted in an estimate that the entire collection of 569,034 messages contained approximately 3,163 relevant messages (with 95% Confidence Interval = 2,456 – 3,869). *Id.* at 16 (Table 5).

52. Grossman & Cormack, *supra* note 29, at 23, 37 (Tables 6 & 7).

53. *Id.* at 37 (Table 7).

The IBM Watson application for playing *Jeopardy!* took a far more dramatic approach to evaluation. In February 2011, in a live *Jeopardy!* contest against two expert players, Watson won by a wide margin (earning $77,147, versus $24,000 and $21,600 for its two human opponents).[54] The Watson team utilized a method of developing metrics to measure outcomes not only at each phase, but also for each component in the development of the computer system (performing more than 5,500 independent experiments in three years), in order to determine whether progress was being made.[55] Using metrics for precision (the percentage of questions the Watson system gets right out of those it chooses to answer), percent answered (the percentage of questions the system chooses to answer), and answer confidence (the degree of confidence that a candidate answer is the correct answer), the system's performance accuracy (precision if all questions are answered) gradually improved to the point where Watson was performing at the level of human experts.[56] This overall, end-to-end performance was made possible by hundreds of analytic components—some of which were designed to produce high recall, while others were designed to produce high precision.[57] The problem-solving orientation of the work led naturally to metrics for evaluating not only end-to-end performance, but also component-by-component performance.[58]

C. Scientific Research Studies Methodology

In science, the dedication to developing and testing knowledge for problem solving is matched by the dedication to theory and testing of scientific methodology itself. The scientific and statistical methods that scientific research laboratories use are under constant theoretical review and extension. For instance, the basic scientific method of hypothesis formulation and quantitative testing evolved over the last two centuries into the science of statistics, and informs most of scientific

54. John Markoff, *Computer Wins on 'Jeopardy!': Trivial, It's Not,* N.Y. TIMES (Feb. 16, 2011), http://www.nytimes.com/2011/02/17/science/17jeopardy-watson.html?pagewanted=all&_r=0.

55. *Building Watson*, *supra* note 33, at 77, 75-76 & Figure 9 (discussing and graphing progress on precision and confidence).

56. *Id.* at 64, 70-76.

57. *Id.* at 71-72.

58. As the Watson team reported: "Our metrics and baselines . . . give us confidence that new methods and algorithms are improving the system or to inform us when they are not so that we can adjust research priorities." *Id.* at 66. Also, "system-level advances allowing rapid integration and evaluation of new ideas and new components against end-to-end metrics were essential to our progress." *Id.* at 67.

research.[59] As another example, linguistics and the information sciences develop and evaluate their methodology for developing and measuring knowledge. Here, the MUCs helped refine a model for understanding and generating knowledge useful in information extraction. A common approach in this field is "to separate different levels of linguistic processing into modules that are then pipelined together," such as {sentence delimiter & tokenizer} → {part-of-speech tagger} → {semantic analytics}. The first module (sentence delimiter & tokenizer) breaks texts into sentences, and sentences into words and punctuation;[60] the second module (part-of-speech or POS tagger) takes the words from the first module as input, and tags or labels words as to their part of speech (e.g., noun, verb, adjective);[61] and finally, the third module (semantic analytics) annotates the meanings of the tagged words (e.g., by matching their usage to regular expression patterns) and assembles information about entities or events of interest.[62]

Once researchers focus on performing a practical task, they naturally decompose the task into subtasks, develop component analytics for performing particular subtasks, develop metrics for evaluating performance by subtask and overall, and try to develop the means of improving that performance.[63] More generally, once a research laboratory focuses on solving real problems in society and measures its success or failure in helping to solve those problems, it naturally analyzes the structure of its problem-solving knowledge, as well as its methods for generating that knowledge.

The series of TRECs provides more examples of how technologically assisting human know-how can drive new thinking about knowledge itself. People know how to retrieve documents containing relevant information, how to identify and extract important textual passages from the relevant documents, and how to formulate those

59. *See, e.g.*, WILLIAM L. HAYS, STATISTICS 5 (5th ed. 1994) (social and behavioral sciences); JACOB COHEN & PATRICIA COHEN, APPLIED MULTIPLE REGRESSION/CORRELATION ANALYSIS FOR THE BEHAVIORAL SCIENCES (2d ed. 1983) (behavioral sciences); ABRAHAM M. LILIENFELD & DAVID E. LILIENFELD, FOUNDATIONS OF EPIDEMIOLOGY (2d ed. 1980) (epidemiologic sciences); JEROME P. KASSIRER & RICHARD I. KOPELMAN, LEARNING CLINICAL REASONING (1991) (clinical reasoning in medicine).

60. JACKSON & MOULINIER, *supra* note 23, at 11-12, 74.

61. *Id.* at 14-16, 74.

62. *Id.* at 17-20 (discussing general semantic analysis), 73-74, 79-82 (discussing regular expression matching, template filling, template merging).

63. The same analytical approach could apply to students' education and training to solve particular kinds of problems, an aspect of legal education discussed in Part III of this article. Much of the first year of law school is devoted to developing the ability to identify legal rules and legal arguments found in legal documents (especially judicial decisions).

texts into information about particular objects or events. Systematically measuring and improving the performance of people on these tasks and subtasks should lead to ideas for automating certain subtasks, and attempts to create useful software can lead to re-thinking how these tasks are actually performed. For example, for the document retrieval task of the TREC 2009 Legal Track discussed in the previous section (selecting documents related to the alteration or destruction of evidence), Team H5 reportedly developed a three-step process: (i) defining relevance criteria; (ii) designing search queries with high precision (each query "may capture just a few documents, but nearly all documents so captured will be relevant"); and (iii) measuring precision and recall of query results.[64] Team H5 described its approach as differing from other information retrieval methods because it utilized "an iterative issue-focusing and data-focusing methodology [between steps (ii) and (iii)] that defines relevancy in detail."[65] This example illustrates how systematically attempting to solve problems effectively can lead to analyzing the process by which the underlying knowledge is generated.[66]

The IBM Watson team faced a peculiarly difficult problem: how to design a system that could compete effectively against human experts in playing a subtle and fast-paced language game.[67] To solve this problem, the team designed a high-performance system by developing the "DeepQA approach," a "massively parallel probabilistic evidence-based architecture" which uses "more than 100 different techniques for analyzing natural language, identifying sources, finding and generating hypotheses, finding and scoring evidence, and merging and ranking hypotheses."[68] For example, the team developed analytic components for automatically detecting implicit semantic relations in a text (e.g., the [Author]-[Work] relation in the phrase "a 1984 Tom Clancy thrill-

64. Grossman & Cormack, *supra* note 29, at 40.

65. *Id.*

66. Other examples of developing methods to solve problems involve developing new metrics for evaluating performance. For example, decisions about whether or not a document is relevant to a legal issue can be notoriously difficult, with different human assessors reaching different conclusions. The TREC 2009 Legal Track used an "overlap" metric to evaluate the extent to which the sets of relevant documents selected by two independent assessors are in agreement. *Id.* at 20. Such metrics for measuring degrees of agreement on relevance can then be used to design processes to increase the degree of agreement (i.e., make the assessment process more reliable). On defining relevance in the context of legal document retrieval and the TREC Legal Track, *see* Oard et al., *supra* note 29, at 360-66, 379.

67. For a description of playing the *Jeopardy!* game, *see supra* pp. 891-92.

68. *Building Watson*, *supra* note 33, at 68.

er"),[69] and for automatically extracting and integrating information about entities from collections of documents.[70] Although the use of massive parallel computation was needed to increase the speed of computation in order to compete effectively in real time on *Jeopardy!*,[71] the remaining details of the DeepQA approach were designed to allow Watson to compete with human experts with comparable accuracy and precision.[72] Here, the development of effective knowledge for problem solving led to re-conceptualizing useful structures for question-answering knowledge, as well as possible processes for generating such knowledge.

In the digital age, the task of designing computer systems to solve problems and the task of effectively educating people to solve the same problems have begun to converge. In order to design computer systems that help solve a particular problem, it is useful to know how people go about analyzing and solving that same problem; in order to educate and train students to analyze and solve a particular problem, it is useful to know how computer systems that help solve that same problem are being designed. This convergence makes it even more important that new advances in knowledge are being disseminated, and that a translational effort exists to implement that knowledge in all appropriate contexts.

D. Scientific Research Disseminates and Implements Scientific Knowledge

Finally, science places a high priority on the wide and rapid dissemination of insights, so that the entire community, both scientific and non-scientific, can benefit from and extend the knowledge gains. An example is Folding@home, a collaborative project among university research laboratories, private industry, and community volunteers that uses distributed computing for disease research, with a large portion of the funding provided by the United States National Institutes of Health and National Science Foundation.[73]

Linguistics and information science researchers in universities also partner with private enterprise to develop new tools for delivering

69. Wang et al., *supra* note 33, at 1-4.
70. Fan et al., *supra* note 33, at 2-8.
71. *Building Watson*, *supra* note 33, at 74-75.
72. *Id.* at 68-76.
73. *See About Us*, FOLDING@HOME, http://folding.stanford.edu/English/About (last visited Apr. 23, 2013).

and accessing knowledge in the digital age. Conference series such as MUC and TREC not only develop and evaluate knowledge, but also disseminate and implement it. One of the principal goals of these conferences has been "to increase communication among industry, academia, and government by creating an open forum for the exchange of research ideas."[74] When teams from government, academia and the private sector work collaboratively on problem solving, especially over a sustained period, they tend to develop a community of dialog that shares at least some of the basic knowledge developed. As participants in TREC have concluded:

> One of the most lasting legacies of any TREC track is the research community that coalesces around new research problems. The Legal Track has been particularly rich in this regard, drawing IR [Information Retrieval] researchers, E-discovery service providers, law firms and law schools into a continuing dialog about the challenges of IR, and evaluation of IR, in E-discovery applications.[75]

Understandably, when the knowledge being developed is truly effective at solving problems, there can be a tension between complete disclosure of developed knowledge and not disclosing critical ideas or algorithms.[76] But even researchers on commercial projects often combine publication of conceptual frameworks or approaches with non-publication of algorithms or operational details.[77] However, at least for publicly funded research, the public interest favors wide and quick dissemination.[78]

Public awareness of the effectiveness of new knowledge is increased through media coverage of events such as IBM's Watson competing in *Jeopardy!*, coupled with subsequent publication of the scientific work behind the event.[79] The collaboration leading to such events also generates a community of knowledge centers focused on particular problems. As the IBM Watson team concluded: "We have leveraged our collaboration with CMU [Carnegie Mellon University]

74. *See* TREC, *supra* note 29; *Text Analysis Conference*, *supra* note 22.

75. Oard et al., *supra* note 29, at 377.

76. *See McKinsey Report*, *supra* note 9, at 5 (while external collaboration with other academic and industry laboratories may result from "the perceived need to protect a laboratory's innovations," it is also recognized that "external collaboration can be a valuable source of ideas").

77. *See, e.g.*, the balance between disclosing conceptual frameworks and not disclosing operational details in the IBM publications about the Watson *Jeopardy!* Project. McCord et al., *supra* note 33; Fan et al., *supra* note 33; Wang et al., *supra* note 33.

78. *See, e.g.*, Kenneth Chang, *U.S. Moves to Provide Quicker Access to Publicly Financed Scientific Research,* N.Y. TIMES, Feb. 23 2013, at A9 (reporting on a new federal policy that has "called for scientific papers that report the results of federally financed research to become freely accessible within a year or so after publication").

79. *See, e.g.*, *supra* notes 54, 77.

and with our other university partnerships in getting this far and hope to continue our collaborative work to drive Watson to its final goal, and help openly advance QA [question-answering] research."[80]

III. APPLYING THE SCIENTIFIC RESEARCH PARADIGM TO LEGAL EDUCATION

This part of the article discusses how law schools can apply the scientific research laboratory model to become knowledge centers in society. Law schools are uniquely positioned to bring legal knowledge into the digital age, particularly at a time when computer technology and the digital information explosion are creating difficulties in three distinct but related areas: the substantive legal problems of the clients for legal services, the management of law offices and delivery of legal services, and the education of new lawyers for the profession.[81] Computer technology is creating not only the need to evolve substantive rules in legal areas such as intellectual property, privacy and criminal procedure, but also the opportunity for new ways of conceptualizing, evaluating, and disseminating legal knowledge.[82] Applying the general concept of a knowledge center, as exemplified by scientific research laboratories, demonstrates how traditional institutions of legal education can adapt in order to become effective knowledge centers in the digital age.[83]

80. *Building Watson*, *supra* note 33, at 78.

81. On the challenges and trends in the legal profession in the digital age, *see* RICHARD SUSSKIND, THE END OF LAWYERS? RETHINKING THE NATURE OF LEGAL SERVICES xviii, 27-57 (rev. ed. 2010) (discussing major changes, including "a shift toward 'decomposing' legal work into its constituent tasks and sourcing each in the most efficient way," and "a rapid increase in the impact of various disruptive information technologies"); RICHARD SUSSKIND, TOMORROW'S LAWYERS: AN INTRODUCTION TO YOUR FUTURE 3-49 (2013) (describing the legal profession as in "an unprededented state of flux" due to three main drivers: the 'more-for-less' challenge to legal-service providers, liberalization of the laws and regulations that govern legal services, and disruptive information technologies).

82. *See e.g.*, *id.* at 99-145 (discussing disruptive legal technologies); William D. Henderson, *A Blueprint for Change*, 40 PEPP. L. REV. 461, 479-90 (2013) (discussing the growth in the "All Other Legal Services" subsector of legal services, with a focus on electronic discovery, due diligence projects, and "predictive coding" – using computer technology in the search for information relevant in law); Daniel Martin Katz, *Quantitative Legal Prediction – or – How I Learned to Stop Worrying and Start Preparing for the Data Driven Future of the Legal Services Industry*, 62 EMORY L. J. (forthcoming 2013) (stating that "[i]nformatics, computing and technology are going to change both what it means to practice law and to 'think like a lawyer'").

83. This discussion also addresses the challenges that law schools have traditionally faced as parts of a research university. *See* Mengler, *supra* note 2, at 686-87 (listing, among other challenges, that law schools typically do not confer doctorates and that they rarely generate even modest amounts of government or foundation grants).

A. Focusing on Real, Unsolved Problems of Society

A law school as a knowledge center would target the real, unsolved legal problems of society, and systematically use its resources to help solve those problems.[84] This is especially desirable at a time when the public resources devoted to legal services are inadequate because of an increase in legal complexity, an increase in the demand for legal services, and strained public budgets.[85] Moreover, law schools are investigating new ways to train new lawyers for a transition to legal practice.[86]

However, this is not to suggest that law schools have ignored the legal problems of society. Law schools have traditionally sought to improve legal rule systems and associated policy objectives through scholarly research and publications.[87] Law schools have also increased public access to justice through clinical programs[88] and special projects.[89] But often these efforts are undertaken only by individual faculty members or students, or only outside the core instructional activity of the school. Therefore, for some schools, becoming a knowledge center in the digital age may mean combining these traditional activities with a core, institutional dedication of resources to systematic and long-term knowledge creation. For other schools, it may mean establishing a more fundamental focus on societal problem solving, on par with educating new lawyers for the profession.[90]

84. Perhaps a current phenomenon in scientific research also applies to legal research: whereas innovation traditionally began as research in universities, then made its way to corporate research and development labs and finally to real-world application, today many innovative ideas come from the real world and then later give rise to intensive research. *See* Kaminer, *supra* note 17, at A22.

85. *See, e.g.*, *Testimony of the Legal Aid Society on the Mayor's Fiscal Year 2014 Preliminary Budget: Presented Before the New York City Council* (Mar. 7, 2013), http://www.legal-aid.org/media/167767/testimonynycfy14budget030713.pdf.

86. *See, e.g.*, ROY STUCKEY ET AL., BEST PRACTICES FOR LEGAL EDUCATION (2007) (reporting from the Clinical Legal Education Association's Best Practices Project); SULLIVAN, *supra* note 1 (reporting the results of The Carnegie Foundation for the Advancement of Teaching's Preparation for the Professions Program).

87. *See, e.g.*, Fred R. Shapiro & Michelle Pearse, *The Most-Cited Law Review Articles of All Time*, 110 MICH. L. REV. 1483 (2012) (listing "the 100 most-cited legal articles of all time").

88. Mark Childress, *Programs of Change: Law Schools Explain Their Commitment to Public Service*, WHITEHOUSE.GOV (Oct. 25, 2011, 05:58 PM), http://www.whitehouse.gov/blog/2011/10/25/programs-change-law-schools-explain-their-commitment-public-service.

89. *E.g.*, THE INNOCENCE PROJECT, http://www.innocenceproject.org/ (last visited Apr. 23, 2013).

90. A striking difference between medical education and legal education is how the former integrates the training of new doctors and the conducting of research with operating medical centers and hospitals that deliver medical services to society. *Cf.*, Christopher L. Hinson, *Legal*

Moreover, there are areas of legal decision-making that are understudied, especially from the standpoint of utilizing the new tools of the digital age. One example of an under-studied area is using computers and artificial intelligence to assist in extracting legal rules from legal documents, modeling legal reasoning both theoretically[91] and empirically,[92] and simulating or automating subtasks of fact-finding.[93] The raw inputs needed to analyze legal rules, legal reasoning, and legal arguments are already available. For instance, the Free Access to Law Movement is increasingly providing free access to the sources of legal rules worldwide.[94] The Internet and the World Wide Web have given lawyers access to an expanding universe of information, all of which provides potential evidence to be used in legislative processes, administrative rule-making, and judicial and administrative adjudication.[95] But accurately extracting computable systems of legal rules from the explosion of legislative documents, and effectively making legal arguments in new adjudicatory cases out of the explosion of available information, pose significant problems for the legal community in the digital age.[96]

Informatics: Opportunities for Information Science, 46 J. EDUC. FOR LIBR. & INFO. SCI. 134, 148 (2005) ("A factor in both the success of medical informatics and the limited success of legal informatics may be that law schools have not provided the same kind of integrated training as medical schools have in the delivery of professional services.").

As long as law schools strive to produce valuable services only for students who wish to become lawyers, the dominant source of revenue will be from payment for those services (tuition). If some substantial portion of a school's effort were devoted to solving other problems in society, then the school might attract funding from non-student sources that are seeking value for their investment. To contrast the business plans of science research laboratories, *see supra* pp. 883-85.

91. For pioneering work in legal argumentation theory, *see e.g.*, TERENCE ANDERSON, DAVID SCHUM & WILLIAM TWINING, ANALYSIS OF EVIDENCE (2d ed. 2005); DAVID A. SCHUM, EVIDENTIAL FOUNDATIONS OF PROBABILISTIC REASONING (1994).

92. For an example of a sustained analysis of the legal reasoning of fact-finding in a single case, *see* JOSEPH B. KADANE & DAVID A. SCHUM, A PROBABILISTIC ANALYSIS OF THE SACCO & VANZETTI EVIDENCE (1996).

93. For an example of automating subtasks of analyzing fact-finding, *see* Vern R. Walker et al., A Framework for the Extraction and Modeling of Fact-finding Reasoning from Legal Decisions: Lessons from the Vaccine/Injury Project Corpus, 19 ARTIFICIAL INTELLIGENCE & LAW 291 (2011).

94. *See, e.g.*, Graham Greenleaf, *The Global Development of Free Access to Legal Information*, 1 EUR. J. OF L. & TECH. 42 (2010) (discussing the history of the Legal Information Institutes, the Free Access to Law Movement, and the World Legal Information Institute).

95. *E.g.*, Claire M. Germain, *Legal Information Management in a Global and Digital Age: Revolution and Tradition*, 35 INT'L J. LEGAL INFO. 134, 136-38 (2007) (discussing the "digital revolution" in terms of the increased quantity and speed of information); SUSSKIND, *supra* note 81.

96. For insights into the fundamental change in the way in which information is captured, processed and shared, *see generally* SUSSKIND, *supra* note 81; JAMES GLEICK, THE INFORMATION: A HISTORY, A THEORY, A FLOOD 373-415 (2011); ANDREW BLUM, TUBES: A JOURNEY TO THE CENTER OF THE INTERNET (2012).

Over the last five decades, there have been sustained efforts to apply artificial intelligence to automate at least some legal subtasks. Recent research in artificial intelligence is addressing the challenge of automatically classifying passages in statutory texts, in order to extract legal rules.[97] Other research is focusing on extracting information from legal decision texts.[98] Another line of research is developing to assist attorneys in e-discovery, by collecting and analyzing information within electronically stored documents.[99] In sum, rule-making and adjudicatory legal processes could become more accurate and more efficient, and be open to participation by more stakeholders, with access to new tools of automation to help gather evidence and produce legal arguments in new cases. In addition, rule extraction and argument creation are skills at the core of the education mission of law schools.

Law schools as knowledge centers could organize their extensive resources—their faculties, students, information infrastructures, and

97. On automating the extraction of legal rules from legislative documents, *see e.g.*, C. Biagioli et al., *Automatic Semantics Extraction in Law Documents*, 2005 ICAIL PROC. 133-140 (reporting the results of experiments applying two analytics or annotation modules to paragraphs/provisions within normative legal texts, in order to classify each provision as to its normative type and to identify text fragments within each paragraph that provide argument-values for each normative type); E. Francesconi, *An Approach to Legal Rules Modeling and Automatic Learning*, *in* LEGAL KNOWLEDGE AND INFORMATION SYSTEMS – JURIX 2009 59, 59-68 (G. Governatori ed., 2009) (presenting a knowledge modeling approach that uses NLP and machine learning to support knowledge acquisition from legislative texts, and which separates two components: domain-independent legal knowledge representing rule instances expressed in legislative texts, and domain knowledge of entities that function as predicate-arguments for legislative provision types); E. de Maat et al., *Machine Learning Versus Knowledge Based Classification of Legal Texts*, *in* LEGAL KNOWLEDGE AND INFORMATION SYSTEMS – JURIX 2010 87, 87-96 (R. Winkels ed., 2010) (presenting the results of an experiment comparing machine-learning techniques and a pattern-based classifier in classifying sentences in Dutch legislation); M. Grabmair et al., *Toward Extracting Information from Public Health Statutes Using Text Classification and Machine Learning*, *in* LEGAL KNOWLEDGE AND INFORMATION SYSTEMS – JURIX 2011 73, 73-82 (K. Atkinson ed., 2011) (presenting preliminary results from an experiment extracting semantic information from U.S. state public health legislative provisions, using natural language processing techniques and machine-learning classifiers).

98. For examples of efforts to automate the analysis of legal decision texts, *see, e.g.*, K. Ashley et al., *Automatically Classifying Case Texts and Predicting Outcomes*, 17 ARTIFICIAL INTELLIGENCE & LAW 125-165 (2009) (classifying case texts in terms of factors that strengthen or weaken a legal claim); M. Saravanan et al., *Identification of Rhetorical Roles for Segmentation and Summarization of a Legal Judgment*, 18 ARTIFICIAL INTELLIGENCE & LAW 45–76 (2010) (assigning rhetorical roles to case sentences based on a corpus of 200 Indian court decisions); P. Jackson et al., *Information Extraction from Case Law and Retrieval of Prior Cases*, 150 ARTIFICIAL INTELLIGENCE 239 (2003) (extracting treatment history, such as "affirmed" or "reversed in part"); Marie-Francine Moens et al., *Automatic Detection of Arguments in Legal Texts*, 2007 ICAIL PROC. 225–27 (2007) (classifying as argumentative sentences from the Araucaria corpus, including newspapers and court reports); Raquel Mochales & Marie-Francine Moens, *Argumentation Mining*, 19 ARTIFICIAL INTELLIGENCE & LAW 1, 8 (2011) (generating argument tree structures); L. Thorne McCarty, *Deep Semantic Interpretations of Legal Texts*, 2007 ICAIL PROC. 217 (2007) (extracting sentences describing the holdings of legal cases).

99. *See, e.g.*, *Special Issue: E-Discovery*, 18/4 ARTIFICIAL INTELLIGENCE & LAW 311 (K. Ashley et al. eds., 2010).

their control over their own curricular structures—to help improve legal decision processes in society. For example, law schools could help improve the efficiency of legal decision processes by collaborating with researchers in linguistics and computer science to develop and test new tools for administrative agencies and courts. At one time, particularly in the 1980s, researchers thought that the effective method for capturing legal rules in a computable format was to interview experts in a particular legal domain and formulate computer programs of "if, then" rules that represent the expert's legal knowledge.[100] For various reasons, this effort failed.[101] However, a different approach is being developed today, using published decision documents as the source for extracting legal rules, evidence and argumentation patterns.[102] Legal decisions with explained findings of fact and conclusions of law can provide important elements for knowledge creation: authoritative applications of legal rules and concepts to identified situations[103]; a "ground truth" for examining predictions about outcomes in new cases, with new evidence; patterns for successful and unsuccessful argumen-

100. Philip Leith, *The Rise and Fall of the Legal Expert System*, 1 EUR. J.L. & TECH. 1 (2010) (recalling that in the 1980's it was thought that the method of building a legal expert system was to "take a group of experts off for a few days and get them to lay out the relevant rules of law which can then be moulded into a formalism by a non-expert").

101. *Id.* As Leith states:

> The primary reason why the expert systems project failed was that the ambitions were so difficult to achieve. What was being proposed was really the robotisation of lawyers – that their skills and knowledge could be easily formalised, and that as a process was at heart a quite simple operation – if you knew the rules, then you could give advice. This, unfortunately, proved wrong.

Id. at 6.

102. *See, e.g.*, Walker et al., *supra* note 93 (describing the Vaccine/Injury Project and the process of creating a logic model of the reasoning in a decided case, and describing how insights into human performance of analytical subtasks can lead to insights into techniques for automating those subtasks).

103. Legal rules and concepts are characteristically "open textured," meaning that the extension of the concepts (i.e., correct application to new instances) often cannot be determined in advance of the actual application. *See, e.g.*, Andrew Stranieri & John Zeleznikow, *Knowledge Discovery from Legal Databases – Using Neural Networks and Data Mining to Build Legal Decision Support Systems*, *in* INFORMATION TECHNOLOGY AND LAWYERS: ADVANCED TECHNOLOGY IN THE LEGAL DOMAIN 81, 82-84 (Arno R. Lodder & Anja Oskamp eds., 2006). Stranieri and Zeleznikow provide reasons for thinking that automated knowledge discovery and predicting concept application may work best in situations involving "personal stare decisis" (an individual judge's attempt to be consistent with her own previous decisions involving similar fact patterns) or "local stare decisis" ("the tendency of a group of judges that make up a current court to follow its own decisions"), rather than "traditional stare decisis" ("a court is bound by prior decisions of courts of equal or higher level"). *Id.* at 87-89.

tation[104]; and guidance in retrieving, extracting, and organizing evidence for new arguments and new situations.

The process of mining decision texts for pertinent information involves at least the following major tasks[105]: (1) identifying the important argumentation-relevant information and extracting it from the text; (2) using this information to guide the retrieval of relevant non-decision documents from unstructured resources; (3) extracting relevant information from retrieved documents one at a time; (4) mining and organizing relevant information from multiple retrieved documents and creating a single knowledge base[106]; and (5) suggesting possible arguments based on the information mined, along with an assessment of the significance and likelihood of those arguments' success.[107] These are the tasks that lawyers perform every day and that students in law schools seek to learn how to do. But the overwhelming amount of information available drives a demand for computer software that can assist lawyers, students and legal decision-makers in performing these tasks. To the extent that law schools could figure out how humans go about performing these tasks, these law schools could help develop effective computer systems, as well as improve the methods for teaching these skills to law students.

Law schools as knowledge centers could also marshal the new tools of the digital age, such as legal informatics, to help improve legal services and access to justice outside of the law schools. Law schools could find both academic and private-sector collaborators in this

104. *See, e.g.*, Johnathan Jenkins, *What Can Information Technology Do for Law?*, 21 HARV. J.L. & TECH. 589, 597-99 (2008) (surveying advances in legal argumentation models and outcome prediction).

105. On decomposing legal tasks and automating subtasks, *see* SUSSKIND, *supra* note 81, at 42-52, 87-93.

106. *See, e.g.*, Jenkins, *supra* note 104, at 602-04 (discussing the problem of extracting information from unstructured documents, and the Semantic Web).

107. This multi-faceted approach to mining legal decision documents can help address one factor cited by Leith for the failure of the legal expert system project:

> Proponents of legal expert systems have picked up on the ideology of law as unchanging and missed the observable facts that law is ever changing and constantly being interpreted. I do not mean that law changes gradually over time – it certainly does that – but it also depends largely upon the context in which it is used and how it is used to produce a narrative from the interpreted facts of a situation (and this evidences continual micro-changes, both developmental and revisionary). Thus the weakness of the expert system's formalising process is that it is static and conservative, while real law is dynamic.

Leith, *supra* note 100. Formalizing legal rules without argumentation patterns for applying those rules in particular situations cannot capture an essential aspect of lawyering.

field.[108] "Informatics" is defined as "the study of the structure and properties of information, as well as the application of technology to the organization, storage, retrieval, and dissemination of information."[109] "Legal informatics" is therefore "the application of informatics within the context of the legal environment and as such involves law-related organizations (e.g., law offices, courts, and law schools) and users of information and information technologies within these organizations."[110] A more pointed definition of legal informatics would be patterned on the American Medical Informatics Association's definition of biomedical informatics, which emphasizes the problem-solving nature of the discipline: "the interdisciplinary field that studies and pursues the effective uses of biomedical data, information, and knowledge for scientific inquiry, problem solving, and decision making, driven by efforts to improve human health."[111] Similarly, law schools

108. *Cf.* Hinson, *supra* note 90, at 135, 148 (stating that as of that time, "scholars in the field of law have not indicated any significant interest in pursuing a legal informatics research agenda with members of the information science community," and discussing "the insularity of legal scholars from those in other fields including information science"). By contrast, the American Medical Informatics Association (AMIA) is a professional scientific organization formed nearly 25 years ago, in 1989, by the merger of three other organizations dedicated to informatics applications in health care. *See* AMERICAN MEDICAL INFORMATICS ASSOCIATION, http://www.amia.org/about-amia/mission-and-history (last visited Apr. 23, 2013).

109. Sandra Erdelez and Sheila O'Hare, *Legal Informatics: Application of Information Technology in Law*, 32 ANN. REV. INFO. SCI. & TECH. 367, 367 (1997) (drawing upon a general definition of informatics by the American Library Association to define legal informatics).

110. *Id.* On the history of legal informatics generally, *see e.g.*, Abdul Paliwala, *A History of Legal Informatics: An Introduction to the Special Issue*, 1 EUR. J.L. &TECH. 1 (2010); *see also,* the articles included in *Special Issue on Legal Informatics*, 1 EUR. J. L. & TECH. (2010), *available at* http://ejlt.org//issue/view/1. For examples of the variety of topics under the heading "legal informatics," see the articles in 39 N. KY. L. REV. (2012) (Special Law & Informatics Issue).

111. Casimir A. Kulikowski, et al., *AMIA Board White Paper: Definition of Biomedical Informatics and Specification of Core Competencies for Graduate Education in the Discipline*, 19 J. AM. MED. INFO. ASSOC. 931-38 (2012), *available at* http://jamia.bmj.com/content/19/6/931.full.

Biomedical informatics faces many challenges that are also of interest to legal informatics. *See, e.g.*, S. Trent Rosenbloom et al., *Data from Clinical Notes: A Perspective on the Tension Between Structure and Flexible Documentation*, 18 J. AM. MED. INFORM. ASSOC. 181 (2011) (discussing the sources of tension between two approaches to obtaining structured data from clinical electronic health records: using structured data-entry systems vs. using flexible documentation to increase expressivity, followed by text processing algorithms); Nicole Gray Weiskopf & Chunhua Weng, *Methods and Dimensions of Electronic Health Record Data Quality Assessment: Enabling Reuse for Clinical Research*, 20 J. AM. MED. INFORM. ASSOC. 144 (2013) (identifying five dimensions of data quality in electronic health records, based on a review of clinical research literature: completeness, correctness, concordance, plausibility, and currency; also reporting seven broad categories of data-quality assessment methods).

The task of using natural language processing (NLP) techniques to extract information from electronic health records, combining that information with medical information from external sources, and using that combined information to provide evidence-based care in a personalized, context-sensitive situation is similar in many respects to the legal problem of extracting information from case-specific evidence and from general legal databases to generate context-appropriate legal arguments. *See, e.g.*, Dina Demner-Fushman et al., *What Can Natural Language*

as knowledge centers could study and pursue the effective uses of legal information and knowledge for problem solving in society, driven by efforts to improve legal services and access to justice.

The Vaccine/Injury Project (V/IP) at Hofstra Law's Research Laboratory for Law, Logic and Technology (LLT Lab) is one example of a research program in this direction.[112] The LLT Lab has a general focus on improving the accuracy and efficiency of health-care claims or adjudication processes, and V/IP is one project within this broad area.[113] The Vaccine Injury Compensation Program (VICP) in the United States is a federal, hybrid administrative-judicial system for expeditiously adjudicating compensation claims involving vaccine-related injuries.[114] Claims are decided by one of eight special masters in the Office of Special Masters within the Court of Federal Claims.[115] The Lab's

Processing Do for Clinical Decision Support?, 42 J. BIOMED. INFORM. 760 (2009) (reviewing the literature on advances in using NLP techniques to provide computerized clinical decision support in a medical setting); Meryl Bloomrosen & Don E. Detmer, *Informatics, Evidence-Based Care, and Research; Implications for National Policy: A Report of an American Medical Informatics Association Health Policy Conference,* 17 J. AM. MED. INFORM. ASSOC. 115 (2010) (reporting the findings and recommendations of the American Medical Informatics Association 2008 Health Policy Conference, which was convened "to focus and propel discussions about informatics-enabled evidence-based care, clinical research, and knowledge management," and presenting "a model of an evidence continuum that is dynamic, collaborative, and powered by health informatics technologies").

112. For details of the Vaccine/Injury Project, see the LLT Lab's website, http://lltlab.org/index.php/site/vaccine-injury-project (discussing the project's study objectives and listing the sample of decisions analyzed). *See also* Vern R. Walker et al, *A Process Approach to Inferences of Causation: Empirical Research from Vaccine Cases in the United States*, LAW PROB. & RISK (forthcoming 2013) (reporting on the VICP, V/IP and in particular the causation inference); Walker et al., *supra* note 93 (describing the Vaccine/Injury Project Corpus, a collection of vaccine compensation decisions together with models of the logical structure of the reasoning of the fact-finders in those cases).

113. Another LLT Lab project within health-care adjudication is the Comparative Medical Accident Liability Project (Comp-MAL Project), which extracts and represents the fact-finding reasoning from medical malpractice cases decided under the Federal Tort Claims Act. These cases are decided by bench trials, without juries, and provide judicial decisions whose reasoning can be compared to that found in medical malpractice decisions in Europe. *See, e.g.*, Giovanni Comandé, *Legal Comparison and Measures: It's Logic to Go Beyond Numerical Comparative Law*, *in* STUDI IN ONORE DI ALDO FRIGNANI, NUOVI ORIZZONTI DEL DIRITTO COMPARATO EUROPEO E TRANSNAZIONALE 173-202 (2011) (using the LLT Lab's default-logic framework to compare the rule trees for medical malpractice liability in the United States and in Italy, and thereby illustrating "research that is much more effective both in detecting variances and similarities as well as placing specific phenomena within the context of a legal system"); *cf.* CASES ON MEDICAL MALPRACTICE IN A COMPARATIVE PERSPECTIVE 1-2, 267-310 (Michael Faure & Helmut Koziol eds., 2001) (using specific fact patterns based on actual cases to compare outcomes and legal reasoning in medical malpractice adjudications in nine European countries, "to examine whether some general tendencies can be found with respect to evolutions in medical malpractice law and their economic effects").

114. Walker et al., *supra* note 112, at 2.

115. 42 U.S.C. § 300aa-12(c), (d) (2006) (directing that the decision of the special master shall "include findings of fact and conclusions of law," and "be issued as expeditiously as practicable"). A goal of the VICP is to provide an efficient compensation system, utilizing a no-fault alternative

V/IP studies the fact-finding reasoning on the issue of causation (whether the vaccine caused the injury) in the most complex cases.

The strategy of the LLT Lab is to extract the fact-finder's reported reasoning from the evidence to the findings, to represent the logical structure of that reasoning using a default-logic framework, and to identify features or patterns in that reasoning that help predict success or failure in argumentation.[116] Through this work, the LLT Lab addresses at least three major problem areas in society. First, it can help improve the accuracy and efficiency of the VICP claims process, by making available on the LLT Lab's website the methodology that the Lab employs, the Lab's case reasoning models, and the Lab's insights into effective argumentation in future vaccine cases.[117] Second, the Vaccine/Injury Project can assist researchers in the linguistic and information sciences by creating a database of analyzed legal decisions, extracted sentences, and logic models. These can be used for machine learning to automate document retrieval, information extraction, and argumentation mining in the legal domain.[118] Third, the Lab trains student researchers in logical analysis and factual argument, while at the same time evaluating the effectiveness of its own training program as an educational process. The LLT Lab therefore fuses legal practice, research, and education into a single program, whose primary objective is to help solve real problems in society.

to traditional tort litigation. *See April 2006 Strategic Plan for the VICP*, HEALTH RES. & SERVS. ADMIN. (Mar. 30, 2013), www.hrsa.gov/vaccinecompensation/strategicplan406.pdf.

On the VICP generally, *see* Laura A. Binski, *Balancing Policy Tensions of the Vaccine Act in Light of the Omnibus Autism Proceeding: Are Petitioners Getting a Fair Shot at Compensation?*, 39 HOFSTRA L. REV. 683, 683-721 (2011); Betsy J. Grey, *The Plague of Causation in the National Childhood Vaccine Injury Act*, 48 HARV. J. ON LEGIS. 343, 343-414 (2011); James B. Currier, *Too Sick, Too Soon?: The Causation Burden Under the National Vaccine Injury Compensation Program Following De Bazan v. Secretary of Health & Human Services*, 19 FED. CIR. B.J. 229 (2009); Vern R. Walker, *Designing Factfinding for Cross-Border Healthcare*, 3 OPINIO JURIS IN COMPARATIONE, 1, 1-40 (2009); Katherine E. Strong, *Proving Causation Under the Vaccine Injury Act: A New Approach for a New Day*, 75 GEO. WASH. L. REV. 426 (2007).

116. *See, e.g.*, Walker et al., *supra* note 112; Walker et al., *supra* note 93 (describing the Vaccine/Injury Project Corpus, a collection of vaccine compensation decisions together with models of the logical structure of the reasoning of the fact-finders in those cases, and discussing subtasks in the extraction process and insights into possible approaches to automating certain subtasks); Vern R. Walker, A Default-Logic Paradigm for Legal Fact-Finding, 47 JURIMETRICS 193 (2007) (laying out the default-logic framework used by the LLT Lab).

117. *See* LLT LAB: VACCINE/INJURY PROJECT, http://lltlab.org/index.php/site/vaccine-injury-project (last visited Apr. 23, 2013).

118. For insights and suggestions on how to automate the extraction of legal reasoning from decision documents in vaccine-compensation cases, *see* Walker et al., *supra* note 93.

B. Evaluating Knowledge Effectiveness

Scientific research laboratories evaluate the effectiveness of the knowledge they develop when solving the real problems they address. Likewise, law schools as knowledge centers would test the effectiveness of legal knowledge on real decision processes in society. Improving legal services and increasing access to justice, however, will often require more than merely making legal information available in traditional formats. Information might be provided, but a lack of knowledge in the community might hinder the use of that information to effectively address the problems. For legal research, even more than for scientific research, it may be important to engage in community-based participatory research ("CBPR"). CBPR is research conducted by a partnership between traditionally trained experts and members of the community that have a stake in solving the problem.[119] Unlike traditional research, in which academicians define and control the research, CBPR is a process in which research, analysis, and implementation are diffused among the partners towards a common community-based goal.[120] CBPR generally involves: facilitating collaborative and equitable partnerships in all phases of the research; integrating knowledge and action for mutual benefit of all partners; conducting a cyclical and iterative process; and disseminating findings and knowledge gained to all partners.[121] Law schools as knowledge centers, for example, could

119. CBPR has been defined in the health sciences as "a collaborative approach to research that equitably involves all partners in the research process and recognizes the unique strengths that each brings. CBPR begins with a research topic of importance to the community and has the aim of combining knowledge with action and achieving social change to improve health outcomes and eliminate health disparities." Definition developed and adopted by the Community Health Scholars Program, *see Community Track*, KELLOGG HEALTH SCHOLARS PROGRAM, http://www.kellogghealthscholars.org/about/community.cfm (last visited Apr. 23, 2013); *see also* Zubaida Faridi et al., *Community-Based Participatory Research: Necessary Next Steps*, CDC (July 2007), *available at* http://www.cdc.gov/pcd/issues/2007/jul/06_0182.html.

In the area of health care, there is growing emphasis on involving patients "as partners in the generation, translation, adoption, and evaluation of evidence-based research." Bloomrosen & Detmer, *supra* note 111, at 117-18, 121 (reporting a model for a "dynamic and collaborative evidence continuum" in research and practice, involving the processes of generating evidence, translating evidence for use in care delivery, disseminating and implementing evidence in the clinical environment, and adopting and assessing effectiveness of evidence-based interventions).

120. *Id.* ("In traditional research, academicians define the research issues, determine how research is done, and decide how outcomes are used. University-based departments and professional schools are generally the arbiters of who has the appropriate knowledge to define research and who is qualified to perform it. In contrast, CBPR is predicated on mutual ownership of the research process and products as well as shared decision making.")

121. *See, e.g.*, COMMUNITY-CAMPUS PARTNERSHIPS FOR HEALTH, http://depts.washington.edu/ccph/commbas.html#Principles (last visited Apr. 23, 2013); THE DETROIT COMMUNITY-ACADEMIC URBAN RESEARCH CENTER, http://www.detroiturc.org/about-cbpr/cbpr-principles.html (last visited Apr. 23, 2013); Barbara A. Israel et al., *Review of Communi-*

partner with governmental regulatory agencies, affected community members, and interested legal service providers, in order to develop, implement and test problem-solving knowledge related to regulatory decision-making in society. Law schools could collaborate with researchers in sociology, psychology, education and economics to measure any effects of implemented knowledge on the targeted problems.[122]

Major tasks within most processes of legal decision-making involve first, the retrieval of relevant documents, then the extraction of relevant information from those documents, and finally, the structuring of a knowledge framework for using that information to help reach accurate, effective, just and fair decisions. The accuracy, effectiveness and efficiency of decision-making might be improved by helping to automate relevant subtasks. One example of law schools addressing the problem of providing digital access to legal documents is the establishment of the Legal Information Institutes (LIIs) and the Free Access to Law Movement.[123]

A major goal of the LLT Lab is to improve the accuracy and efficiency of adjudication processes in general, and vaccine-injury compensation claims in particular. The Lab models the logic of the fact-finder's reasoning in decided cases and makes that knowledge available to decision makers, attorneys and affected parties for use in new cases.[124] The effectiveness of the knowledge generated by the Lab will be measured by its usefulness to participants in adjudicatory processes (e.g., in determining the settlement value of cases), and by changes in the accuracy and efficiency of those processes. In addition, one way to further that goal is to develop reliable, accurate and cost-effective methods of extracting logical structure from legal decisions.[125] To this end the Lab undertook a study of the major subtasks involved in performing that modeling (i.e., decomposed subtasks involved in extracting the structure of the logical reasoning). Such subtasks included:[126]

ty-Based Research: Assessing Partnership Approaches to Improve Public Health, 19 ANN. REV. OF PUB. HEALTH 173, 178-180 (1998).

122. Metrics and measurements would be needed to evaluate the effectiveness of any new knowledge developed. *See, e.g.*, Paul Hellyer, *Assessing the Influence of Computer-Assisted Legal Research: A Study of California Supreme Court Opinions*, 97 L. LIBR. J. 285, 290 (2005) (discussing hypotheses about the possible effects of computer-assisted legal research on judicial decisions, and reporting on a study of California Supreme Court decisions to try to test those hypotheses).

123. *See* Greenleaf, *supra* note 94.

124. *See* Vaccine/Injury Project, *supra* pp. 911-13.

125. *See* Walker et al., *supra* note 93, at 294.

126. *Id.* at 303-28.

identifying and representing legal rules; identifying reference variables and roles; identifying and representing evidentiary assertions; modeling findings of fact and the core structure of counterarguments; sorting sentences and assertions into branches of a rule-tree structure ("horizontal relevance"); organizing sentences and assertions into levels of reasoning within each branch ("vertical relevance"); and assigning plausibility-values to evidentiary assertions in the model that reflect the fact-finder's assessment of the evidence. Researchers then reflected on the "lessons" learned from doing such modeling and training others how to do it, and developed suggestions for automating subtasks within the extraction process.[127] For example, the Lab provided suggestions for identifying the findings of fact in a decision document by considering consistency with higher-level findings (and for locating the ultimate finding in the case), by using the wording of the rule conditions governing the case, and by searching for certain formulaic words used to make findings.[128]

To develop evaluation methodologies, law schools can turn to linguistics and the information sciences for ideas about metrics. For example, in measuring student performance on retrieval tasks, metrics like recall and precision could be very useful in legal education.[129] Researchers in law schools could decompose the activities that lawyers perform (and that law students need to learn how to perform) into subtasks, identify methods for performing each subtask, and evaluate students' performance on discrete subtasks.[130] Many legal-service activities presuppose proficiency at selecting what is relevant from what is irrelevant—activities such as finding relevant legal cases or evidentiary documents, or extracting rules or policies from judicial decisions, or extracting useful evidentiary assertions from discovery documents. The metric of recall would measure how well either a technology-assisted system or a student performs at finding *all* relevant items,[131] while the metric of precision would measure how well the system or student performs at finding *only* relevant items.[132] Once researchers begin to measure system or student performance at these subtasks, they can quantitatively evaluate alternative system designs or alterna-

127. *Id.*

128. *Id.* at 312-14.

129. For definitions of recall and precision, see *supra* text accompanying notes 39-43.

130. On the value of decomposing tasks into subtasks, *see* SUSSKIND, *supra* note 81, at 42-52, 87-93.

131. *See supra* notes 40 and 42 and accompanying text.

132. *See supra* notes 41-42 and accompanying text.

tive methods for teaching and learning these skills, and work to improve those designs or methods. The ability to develop technology for assisting in performing a subtask, and the ability to develop successful instructional methods for learning how to perform the subtask, are in turn evidence that we truly understand how people perform the activity when they do it well.

As discussed above, evaluating the effectiveness of problem-solving knowledge also provides an opportunity for evaluating the effectiveness of pedagogical techniques for teaching that knowledge. For instance, because student membership in the LLT Lab normally begins in the fall semester of the second year of law school, the training process for new members must be both efficient and effective, and occur within a very short time, because new members must learn to use the default-logic framework of the Lab and the Legal Apprentice™ software and begin to create data (logic models) for the V/IP database.[133] The experience of the LLT Lab is that three things work in parallel and reinforce each other: (1) the understanding of how humans perform a subtask; (2) the ability to effectively and efficiently teach humans to perform that subtask well; and (3) the ability to design computer technology to assist in performing that subtask.[134] Law schools as knowledge centers would appreciate the close, symbiotic connection between working effectively to solve societal problems outside the academy and creating an effective educational system inside the academy. Putting legal information to work to help solve societal problems is one description of what a lawyer in society does, and what students in law schools need to learn.

133. The Lab's primary goals in the project are to produce logic models for decided cases: (1) that accurately represent the essential inference structure of the reported decision (descriptive accuracy); (2) that contain sufficient information such that a valid normative critique of the model is also a valid critique of the reported reasoning (normative completeness); (3) that capture important patterns in the reasoning (pattern discovery); and (4) that are useful as tools for understanding the reasoning (comprehension), and potentially for improving litigation support software. Walker et al., *supra* note 93, at 293.

134. For another example of the dynamic among understanding, teaching and automating, *see* Kevin D. Ashley, *Teaching a Process Model of Legal Argument with Hypotheticals*, 17 ARTIFICIAL INTELLIGENCE & LAW 321 (2009) (presenting: examples of patterns of reasoning with hypotheticals in appellate legal argument; a process model for hypothetical reasoning that describes the relationships between an advocate's proposed rule for deciding an issue, the facts of the hypothetical and of the case to be decided, and the legal principles and policies underlying the issues; and a computerized teaching environment LARGO that helps students identify and analyze episodes of hypothetical reasoning); Niels Pinkwart et al., *Evaluating an Intelligent Tutoring System for Making Legal Arguments with Hypotheticals*, 19 INT'L J. OF ARTIFICIAL INTELLIGENCE IN EDUC. 401 (2009) (reporting the results of two studies evaluating the effectiveness of LARGO as a teaching tool for first-year law students).

C. Re-Conceptualizing Knowledge Processes and Structures

While legal scholars traditionally analyze the legal rules and policies from constitutions, treaties, statutes, regulations and decisions, they have put far less effort into articulating the methodology used in conducting such analysis, critiquing and improving the methodology itself through empirical testing, or working toward automating subtasks in applying that methodology. While there are certainly isolated pockets of legal theory on legal reasoning,[135] there is not a concerted, systematic effort within the legal profession to study the distinctive logic of legal reasoning, as compared to the study of experimental design and statistical methods in the sciences. Yet, there is good evidence that legal reasoning has distinctive features—whether it is policy-based or case-based reasoning to support rule adoption, or it is rule-based or case-based reasoning to support fact-finding. Such reasoning is always pragmatic in the sense of balancing the epistemic objective (to reach conclusions that are as accurate as possible, while being warranted by the evidence in the legal record) against the competing non-epistemic objectives (such as promoting vaccine use or improving administrative efficiency).[136] Moreover, such reasoning always occurs in real time, is constrained by limited resources, and is usually based on incomplete information.[137] The LLT Lab is investigating the use of default logic to represent the structure of such reasoning,[138] but other logics, structures and research methods may prove useful as well. The point is that legal education could be pursuing a concerted, systematic inquiry into analytic methodologies employed in law, but it is largely failing to do so.

The tasks of document retrieval, information extraction, and data mining require that legal knowledge be represented in new ways. For example, the retrieval of relevant documents is the primary target

135. As examples, for the study of the probative value of the forensic sciences in criminal law, *see* DAVID L. FAIGMAN ET AL., SCIENCE IN THE LAW: FORENSIC SCIENCE ISSUES (2002); for the study of the adequacy of reasoning in expert opinions for purposes of admissibility in federal court, see the literature following the Supreme Court trilogy of Daubert v. Merrell Dow Pharms., Inc., 509 U.S. 579 (1993), Gen. Elec. Co. v. Joiner, 522 U.S. 136 (1997), and Kumho Tire Co. v. Carmichael, 526 U.S. 137 (1999); for the study of general patterns of evidence evaluation since Wigmore, *see* TERENCE ANDERSON ET AL., ANALYSIS OF EVIDENCE (2d ed. 2005); JOSEPH B. KADANE & DAVID A. SCHUM, A PROBABILISTIC ANALYSIS OF THE SACCO AND VANZETTI EVIDENCE (1996); DAVID A. SCHUM, THE EVIDENTIAL FOUNDATIONS OF PROBABILISTIC REASONING (1994).

136. Vern R. Walker, *Discovering the Logic of Legal Reasoning*, 35 HOFSTRA L. REV. 1687, 1690-93 (2007) (characterizing the pragmatic nature of legal reasoning).

137. *Id.*

138. *See supra* note 116.

function of "Electronic Data Discovery" ("EDD") or "e-discovery,"[139] which has become a major legal service being advanced by both commercial[140] and academic researchers.[141] The process of retrieving documents for discovery, however, is not a single task, but decomposes into at least four tiers of tasks: (1) identifying content and scope of relevant materials, and collecting materials into a searchable medium; (2) indexing and vetting the collected materials (e.g., by filtering out duplicates and organizing materials into clusters); (3) searching and organizing the vetted materials, by classifying, clustering and tagging them; and (4) analyzing the materials and reporting the final work product.[142] Conrad suggests that as one moves from task-tier (1) to task-tier (4), "the enabling technologies involved become more advanced, requiring state of art information analysis and synthesis techniques."[143] As every senior researcher or lawyer probably experiences, the helpfulness of the work of novice researchers or lawyers diminishes as the work progresses through these same task-tiers. Technology-assisted performance of such higher-tier tasks would probably require the application of artificial intelligence techniques.[144] Such higher-tier tasks might include the formulation and testing of theories or hypotheses about relevance ("a more-or-less abstract description of subject matter that, if found in a document, would make that document relevant"), and machine learning and new tools "for eliciting, representing,

139. For a definition of EDD or e-discovery, *see e.g.*, Conrad, *supra* note 29, at 321, 322 (defining EDD as "any process (or series of processes) in which electronic data is sought, located, secured, and searched with the intent of using it as evidence in a civil or criminal legal case").

140. *See, e.g., id.* (stating that "[t]he first billion dollar year for E-Discovery took place in 2005," and one estimate that "[i]n 2010, the industry expect[ed] a total revenue of between four and five billion dollars"). An estimate for revenue in e-discovery consulting services in 2012 was $1 billion. *e-Discovery Consulting Services in the US: Market Research Report*, IBISWORLD (Aug. 2012), http://www.ibisworld.com/industry/e-discovery-consulting-services.html. An estimate for total revenue in the e-discovery software market in 2012 was $ 1.4 billion. Andrew Bartholomew, *E-Discovery Software Market Experiencing Accelerated Growth*, EXTERRO (Jan. 8, 2013), http://www.exterro.com/e-discovery-beat/2013/01/08/e-discovery-software-market-experiencing-accelerated-growth/.

141. Over the first four years of the government-sponsored research called TREC Legal Track, the participants in the interactive task went from consisting of almost exclusively academic institutions in 2006, to having non-academic, non-governmental participants make up the vast majority in 2009. Conrad, *supra* note 29, at 332 & Table 1.

142. For lists of subtasks in e-discovery, *see e.g.*, *id.* at 324-25, 334 (proposing the "E-Discovery Pyramid," whose four tiers correspond to those listed in the text of this article);

143. *Id.* at 334.

144. Artificial intelligence means "the development of formal or computational models of legal knowledge, reasoning, and decision making." *Aims and Scope*, 21 ARTIFICIAL INTELLIGENCE & LAW (Mar. 2013).

implementing, and reasoning with litigators' hypotheses or theories of document relevance."[145]

Using information to generate evidence and using that evidence to formulate effective legal arguments also requires new ways of representing knowledge products. Retrieving and producing relevant documents in response to a discovery request is a first stage in extracting information for purposes of constructing legal arguments, but it is only the first stage.[146] As difficult as this task can be, it is even more difficult to turn the documents received in discovery into evidence and then to produce the legal arguments based on that evidence that are effective in court.[147]

The LLT Lab takes an empirical approach: by analyzing patterns of proof that have been successful or unsuccessful in the past, it gains insight into how to construct more effective arguments in the future. In order to accurately represent and compare the logical structure of reasoning in legal decisions, the Lab models reasoning using a default-logic framework.[148] A logic model for a case has two major parts, representing (a) the system of legal rules that governs the fact-finding and (b) the fact-finder's assessment of the evidence while applying those rules to the particular case.[149] First, the system of legal rules is represented by an inverted "rule tree," with the ultimate issue to be decided at the top and with the branches extended downward representing the legal conditions for proving that ultimate issue. The tree consists of three-value propositions (true, undecided or false) connected by logical operators. Second, the evidence assessment in a particular case is added to the rule-tree branches by attaching findings of fact, which are

145. Kevin D. Ashley & Will Bridewell, *Emerging AI & Law Approaches to Automating Analysis and Retrieval of Electronically Stored Information in Discovery Proceedings*, 18 ARTIFICIAL INTELLIGENCE & LAW 311, 313-18 (2010).

146. For an inclusive definition of e-discovery that covers document retrieval for various legal purposes beyond mere production in discovery, *see* Conrad, *supra* note 139, at 322.

147. Hypotheses or theories of document relevance could supply not only criteria for document retrieval, but also criteria for extracting the information useful in argumentation. For example, Ashley and Bridewell suggest that a "hypothesis ontology" (containing such relations as *communicated-with* and *during-interval*) could be used to formulate a relevance hypothesis such as: "There exist documents in which Alice *communicated-with* Bob *during-interval* 1976-1978 that *contain-keywords* {tobacco, children, advertising}." Ashley & Bridewell, *supra* note 145, at 317-18. Presumably, such documents would be relevant because they could provide information that fits (for example) into the litigator's theory for proving liability in the civil litigation.

148. *See supra* note 116; Vern R. Walker, *Visualizing the Dynamics Around the Rule-Evidence Interface in Legal Reasoning*, 6 LAW, PROB. & RISK 5-22 (2007); Vern R. Walker, *Emergent Reasoning Structures in Law*, *in* HANDBOOK OF RESEARCH ON AGENT-BASED SOCIETIES: SOCIAL AND CULTURAL INTERACTIONS 305-24 (G. Trajkovski & S.G. Collins eds., 2009).

149. *See* Walker et al., *supra* note 93, at 294-301.

supported by inferences grounded on evidence in the legal record. Evidentiary assertions are assigned degrees of plausibility and are connected together by plausibility operators. This framework allows researchers to accurately represent the reasoning in decided cases, to make comparisons among cases over time, and to study the successful and unsuccessful patterns of reasoning and proof.[150] Moreover, this structure renders this type of legal knowledge more computable and more useful in the digital age.[151] Therefore, the Lab's methodology provides an example of re-conceptualizing the structure of legal knowledge.

Automation provides another important way of assessing the adequacy of a methodology or a knowledge structure. As the LLT Lab investigates the possibility of automating at least some of the subtasks involved in extracting logical reasoning from legal decision documents,[152] it develops theories about what features or patterns of evidence or reasoning are predictive of argumentation success or failure. The predictive features of argumentation might apply to only specific branches of reasoning in the case, and not to the case as a whole. The Lab can then develop hypotheses about those predictive features, and test those hypotheses against other decided cases. If certain features do indeed affect the probability of an outcome (either positively or negatively), then a useful knowledge base about cases would contain information about those features. Using predictive features would require generating and storing a new kind of knowledge about the evidence in the case. In addition, with even moderately large collections of legal decisions, computer software would be helpful in coding decided cases for those features, and in providing a user interface for practicing attorneys who are trying to determine whether those features are present in new cases. Thus, focusing on solving real questions faced by legal services leads to re-conceptualizing our knowledge about the law.

150. For the LLT Lab's primary goals in conducting this modeling, *see supra* note 133.

151. *See, e.g.*, Walker, *Emergent Reasoning, supra* note 148, at 305-24. In creating these logic models, the Lab uses the Legal Apprentice™ software from Apprentice Systems, Inc., as the working environment in which the models are created. The software automatically creates XML-formatted files of the logic models, which is a standard format used in Internet-based programs. The LLT Lab also makes HTML versions of these logic models available to the public on its website, *Our Work Products*, LLT LAB, http://lltlab.org/index.php/site/work-products (last visited Apr. 23, 2013).

152. *See We Make Practical Tools*, LLT LAB, http://lltlab.org/index.php/site/LLT_Lab-Work-Products_post/we_make_practical_tools (last visited Apr. 23, 2013).

D. Disseminating and Implementing New Knowledge

Law schools have traditionally disseminated the knowledge that they have generated—for example, by providing courses and classes[153]; publishing articles, books and other works; presenting information at workshops and conferences[154]; and participating in external committees, expert panels and advisory boards. Also, numerous individual legal scholars are conducting similar activities using various Internet tools. Moreover, some institutions, such as the Legal Information Institutes (LIIs), address the problem of disseminating legal information by publishing it for free access via the Internet.[155] The LIIs, with the first one started at Cornell University Law School in 1992, collaborate with each other through joint membership in the Free Access to Law Movement.[156] But generally, law schools have only used the Internet primarily for institutional webpages, for connecting with students and alumni through social networking, and as a means of delivering courses online.[157]

A law school as a knowledge center in the digital age would use the Internet not merely as a medium for transmitting legal information, but also as a means of applying various forms of legal knowledge in helping to solve legal problems.[158] Such possibilities

153. On a view of "the talk, chalk and Casebook/Textbook culture" from the perspective of the digital age, *see* Abdul Paliwala, *Socrates and Confucius: A Long History of Information Technology in Legal Education*, 1 EUR. J.L. & TECH. 225 (2010) (discussing three approaches to legal pedagogy: the lecture method, the Langdellian (Socratic) mode, and the Realist/Pragmatist (Confucian) methods).

154. Notable in combining a traditional conference format with the opportunities presented by the digital age are the "Law Via Internet" (LVI) conferences of the Free Access to Law Movement, which traces its origins to Cornell Law School in Ithaca, NY, in 1992. *2012 Law Via the Internet Conference*, LEGAL INFORMATION INSTITUTE, http://blog.law.cornell.edu/lvi2012/ (last visited Apr. 23, 2013); Greenleaf, *supra* note 94, at 50-52.

155. *See id.*

156. *Id.* at 44.

157. For a review of online legal education, *see, e.g.*, *Distance Learning in Legal Education: A Summary of Delivery Models, Regulatory Issues, and Recommended Practices*, THE WORKING GROUP FOR DISTANCE LEARNING IN LEGAL EDUCATION, http://www.law.harvard.edu/programs/plp/pdf/Distance_Learning_in_Legal_Ed.pdf (last visited Apr. 23, 2013).

158. As Noveck has suggested, in writing about Wikipedia and legal education:

> The pedagogic literature is unambiguous in its recommendation of activist and engaged modes of learning. We ought to teach students, not only how to read wikis critically and check facts, but how to *write* them. Instead of forbidding access to Wikipedia, why not require students to edit or write an entry? Let them be producers, not just consumers of knowledge!

Beth Simone Noveck, *Wikipedia and the Future of Legal Education*, 57 J. LEGAL EDUC. 3, 7 (2007). A law school that became a knowledge center in a particular substantive area might undertake to write, contribute to, or maintain related pages in Wikipedia.

have been investigated since 1990 in the SubTech conference series, a series of bi-annual international conferences that have explored not only computer-aided instruction, but also artificial intelligence and knowledge management, legal-practice technologies, and legal research and databases.[159] There are other examples. Web 2.0 makes possible a platform of services (not just a collection of links), and "users [can] become co-developers of applications," such as law blogs, collaborative encyclopedias, and RSS syndication.[160] The Center for Computer-Assisted Legal Education (CALI), established in 1982, has long provided web-based tutorials on a variety of legal subjects, sponsors an annual conference with computer-related programming for law school professionals, and has recently joined the Free Access to Law Movement.[161] Learning management systems (LMSs), such as Blackboard and TWEN, are software applications for administering, delivering, and documenting education courses over the Internet.[162] And recently, "massive open online courses" (MOOCs), which began as free online university courses with massive enrollments, are not only disseminating knowledge widely, but also potentially providing a means of soliciting, compiling, and "re-purposing" knowledge.[163] With these examples in mind, one next step is for law schools to provide legal-knowledge services through Internet servers, and partner with the private sector to develop software applications for accessing cloud-stored databases by means of mobile devices.

Today's legal problems are often systemic, complicated and long-term, and the most effective approach to solving them is collaboration (much of it inter-disciplinary), teamwork, and institutional commitment. Effective collaboration and efficient team approaches, however, may require the development of management structures that are unfamiliar to most traditional law schools. For example, the strategic plan for the LLT Lab includes strategic research objectives and strategic education objectives. Strategic research objectives include developing reliable and valid techniques for modeling patterns of legal reasoning,

159. Marc Lauritsen, *SubTech: An Overview*, 2(1) EUR. J.L. & TECH. (2011), *available at* http://ejlt.org//article/view/67.

160. Germain, *supra* note 95, at 140-43.

161. *About CALI*, THE CENTER FOR COMPUTER-ASSISTED LEGAL EDUCATION, http://www.cali.org/content/about-cali (last visited Apr. 23, 2013).

162. *Learning Management System,* WIKIPEDIA, http://en.wikipedia.org/wiki/Learning_management_system (last visited Apr. 23, 2013); *Workshop on the Future of the Legal Course Book*, 33 SEATTLE U. L. REV. 292, 329-31 (2010) (discussing the need for an open industry standard for learning management systems).

163. *See* Todd E. Pettys, *The Analytic Classroom*, 60 BUFF. L. REV. 1255, 1293-99 (2012).

as well as a management structure that facilitates a team approach to knowledge generation, so that research programs will be scalable. This requires developing methodologies and management structures that permit researchers at different locations and different times to divide up the work and to conduct coordinated research projects. Strategic education objectives include developing modular courses that teach analytic logic skills, which can be offered as distance education over the Internet.

A major theme of this article is that solving societal problems, doing productive research, and providing effective education are objectives that are closely related to each other. Just as legal-knowledge centers would collaborate with each other, they would also partner with other academic disciplines, and with governmental institutions, private enterprises and the affected communities, in order to work effectively and efficiently at problem solving. As a result, better structures are needed, both within and between law schools, for coordinating research on real, unsolved problems.

CONCLUSION

Scientific research laboratories, as concrete examples of knowledge centers, efficiently fuse research, education, and practice – by educating new scientists while conducting meaningful research into practical problems. Every research project is an opportunity to provide new solutions to real problems, to create new and effective knowledge, and to train students, all with the same expenditure of resources. This article suggests that a similar core mission could provide similar benefits for law schools. In addition, the paradigm of a scientific research laboratory suggests a working model for how law schools could function more effectively as knowledge centers for society in the digital age. By targeting the solution of legal problems in society, by developing new forms of legal knowledge, and by creating new digital tools that are designed to help implement those solutions, law schools have the opportunity to move law into the digital age, while still doing research and training new legal professionals. Finally, this article raises important questions about how law schools as legal-knowledge centers might best collaborate among themselves, and partner with other academic disciplines, government, private enterprise, and the community—to advance the work of improving legal processes and services within society, while at the same time conducting research and promoting effective legal education.