Technology at the Crossroads: Implications for the Liberal Arts

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*Liberal Learning in a Technological Age*

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1. The Crossroads of Liberal Learning

1.1. 'Techne,' 'Technology,' and the 'Liberal Arts'

When controversy on innovation in liberal arts education is joined there is typically a lot of talk about the origin and meaning of the liberal arts. Much of this discussion, variously, takes flight on the wings of metaphor, comes to ground in argument from classical authority, takes root in etymological erudition, or waxes nostalgic about nineteenth century ideals.

This academic doxology can be as tedious a ritual as it is obligatory. But for humanists to forget their roots is suicidal. For philosophers to fail to define their terms is anathema. So, in addressing the need for a new agenda in liberal arts education, and roles for the computer and other technology in that agenda, I will say something about tradition and terminology, about what I take the philosophical mission of liberal arts education to be, and how that mission might assume new and powerful forms in our own contemporary institutional settings.

To combine the obligatory (and telling) metaphor with collateral appeals to etymology and classical (if not exactly ancient) authority:

One venerable model of liberal arts education began with a core curriculum called the trivium, whose name derived from tri via, in Latin three roads, and meant, colloquially, any place where several roads came together, a crossroads.

Typically, in earlier times, a crossroads was a very remarkable place, a place where people came together outside their normal parochial habitats, where commerce flourished, and cooperative social enterprise perforce emerged — on common ground, with common coin.

The perennial question for the liberal arts in any age is obvious: Where on the map of knowledge lie the crossroads, the common grounds, through which all educated persons would pass in their otherwise disparate journeys through life? What "arts," what intellectual tools, what bodies of learning might constitute a core curriculum for educated people today, the common basis of our diverse intellectual commerce, our common social enterprise, our striving for meaning in life?
Etymology provides convenient clues to the perennial wisdom. For one thing, it seems that other ages did not torture the distinction between knowledge and skill as we like to do today: a certain commensurability is built into the roots of our knowledge-skill terminology from the Middle English back to Latin, Greek, and Sanskrit. *Skill* originally denoted both the discriminating reasoning faculty and the power of recognition, and once meant to know or understand (usually how to do something) as well as to discern and literally separate. *Know* derives from the Sanskrit *gan* as does *can*, *able to*, as well as *ken*, a form of the root that meant both *can* and *know*. With roots so intertwined, how ken we skyll them?

The "arts" in question were indeed instrumental intellectual "skills" (as distinct from pure *scientiae*); but, the *OED* attests, skills gained "as the result of knowledge" as well as "practice." These "branches of learning" were "of the nature of instruments for more advanced studies, or for the work of life." Liberal learning and instrumentality were not unalterably opposed. With values so complimentary, why would we skew them?

And, as we know from the core curriculum of yore (Grammar, Logic, Rhetoric; Arithmetic, Geometry, Music, Astronomy), the philosophy of the liberal arts was not prejudiced in principle against technical "arts" (actually a Greco-Latin redundancy), quantitative tools, or formal artifice: For purposes of preparing people "for the work of life" technological literacy, relative to the state of the intellectual arts of the day, was the very foundation of liberal learning. Liberal learning and a certain basic technological literacy have always been essentially related. Why should this come as news today?

The *techne'* crucial to the liberal arts was never meant to be of the purely mechanical variety, but a nexus of skill and knowledge, of application and discernment, of ability and understanding. *Technology*, before the term came to be associated with the industrial arts in the nineteenth century, concerned the systematic study of the nomenclature, principles, and techniques of the arts generally. *Technology*, if we attend to its roots, portends not thralldom to mechanics and technics, but knowledge (*logos*) and understanding — of the state of the arts, their theory and practice, applications and limitations. Why should we be enthralled or intimidated when knowledge could make us free?

Concern about the elevation or intrusion of any technical component within the liberal arts comes more recently, perhaps, from a preoccupation with their proper "liberal" leanings and an understandable if mistaken tendency to conflate the "liberal arts" with the "humanities." Originally, these arts were "liberal" so far as they were thought suitable as well as essential to "free" men, in a day when only but not all *men* were, by all rights, free. In our democratic
culture this political sense of the term obviously has little cachet. Stripped of its dated class- and gender-consciousness, the essential notion is that the "liberal" arts are supposed to prepare one for higher learning "for its own sake," rather than merely for "servile" occupations or gainful applications. That the liberal arts are meant to be, in any number of senses of the contemporary argot, "liberating" is also surely in the spirit of this ill-defined classical ideal. Who would wish to doubt it?

The perennial wisdom tells us that there are technical bodies of learning and skills, in whatever age, that provide common foundations for the meeting of minds, for intellectual commerce, for cooperative social enterprise, for further travels along any of the many roads to higher learning, and, ultimately, "for the work of life." These "arts" or knowledge-laden skills are supposedly valuable irrespective of whatever "servile" or living-making occupations we might pursue. But this is not to say that they must be irrelevant or literally use-less for furthering our professional or other more practical goals. On the contrary. But their general utility does not preclude wisdom in and through their use. Do the Delphic injunction and its Socratic incarnation, *Know thyself*, not entail the technological imperative *Know thy tool*?

There is an essential tension, perhaps, between the 'liberal' and 'technical' dimensions of the liberal arts. But is it any part of wisdom to further alienate what has existed for so long in such creative tension?

Whatever the tension, the sheer complexity of the contemporary world and its learning make the selection of curricula for honorific status in the liberal arts difficult if not controversial. In the present climate of retrenchment and deference to the growing demand for professionally relevant education in a technology-bound society, controversy is perhaps unavoidable. But shall we shrink from it?

In our pluralistic culture a 'liberal' philosophy of the liberal arts and an artfully experimental approach to their inevitable evolution seem advisable. The notion of a 'liberal' education is sufficiently complex and inherently ill-defined that we are well advised to move modestly within its spirit rather than to cite or attack the letter of it. Dogmatism in educational philosophy is as artless as it is illiberal. Might we not aver with John Stuart Mill that "varied experiments" in education as well as in living are the order of the day?

A kind of Parmenidean paradox for savants seeking the commonplace, crossroads or unity among the liberal arts today is that the one may be many. There likely is no single monomorphastic model of what a liberal education should be. The liberal arts themselves are, in any case, different from what they once were, at least in their particulars if not in their
principles.

So, to call for a 'new' liberal arts agenda in terms of renewed emphasis on technological or, more narrowly, quantitative literacy is not to espouse some contentious heresy, but to recognize, at once, the evolutionary and perennially technical nature of the basic arts (*techne*') with which we must try to comprehend our world, negotiate our increasingly technological society, and, with all, improve our lot.

This much is sure. The arts in question have always been dressed, wisely, in response to the demands of a changing cultural climate and evolving social exigencies. The arts competing for priority billing at the crowded crossroads of higher learning today — and the freedoms their knowledge and application proffer — are many and varied — beyond anything we can assimilate to archaic models of liberal learning (however much we may rightly admire their arche' or architectonic). The arts relevant to the "work of life" are, in any case, not limited to the traditional humanities (and never have been). The technological literacy demanded of us today is beyond compare with anything in the past. And, of course, the computer has arrived at the crossroads — to help or to hinder, as we will.

*As we will.* We humanists are supposedly fond of free choice. The liberal arts are supposed to promote it. Perhaps liberal education, like charity, should begin at home. The computer is certain to revolutionize, or, if that is too dramatic, change the complexion of the liberal arts as well as the ease if not the philosophic purpose with which we teach and apply them.

The question is whether we, as humanists, wish to suffer this change as passive subjects of an aberrant, unbridled technological imperative (*If it can be done, it will be, for better or worse*), or whether we wish to take a hand in this historic happening, directing this powerful new instrument, its attendant technology and applications, to liberal and artful ends.

The answer to the philosophical question may seem be obvious. But its institutional realization is another matter. And, in keeping with the liberal spirit of the education we wish to promote, responses to the need for a new agenda in the liberal arts will vary, as they must, with differences in institutional priorities and settings.
1.2. Institutional Settings: The Humanities at the Crossroads

The metaphor of the crossroads is a telling one for construing the crucial core and function of the liberal arts, even if the nature and status of crossroads have changed in more modern times (Yesterday's crossroads are, after all, today's cities, and we may be hard pressed to find inspiration in that image).

There are doubtless many appropriate ways for the crucial contemporary arts to intersect. While some mix of natural, quantitative, and social science as well as humanities will be found at any intersection, its complexion will vary, as well it should, in different institutional settings, according to different institutional missions and 'experiments.'

But just as the computer has arrived at the crossroads of liberal learning, the humanities have come to a crossroads of their own in this historic evolution of the liberal arts. Different if not necessarily exclusive options are open to the humanities as they define their role and educational priorities in line with either a more traditional or more innovative liberal arts agenda.

One road taken by the humanities in many institutions is the more traditional one, the pursuit of the perennial wisdom through the study of its historic roots and great books, a kind of cultural archeology. This was part of the original mission of humanistic learning in the Renaissance and in its precursor in the High Middle Ages.

Another road, leading presumably to the same destination in cultural space but looking frightfully like a wrong turn to many, leads by various detours through some very sophisticated technological territory and branches by alternate routes into centers of professional learning. The computer is an obvious vehicle of choice for negotiating this route. The social and mathematical sciences tend to compete vigorously for the fast lane here, as against the humanities, as well as for the resources to make way. It is not that the humanities are being deliberately forced off the road but that little is taken for granted regarding who has what right-of-way. It is simply that the humanities must be robust and enterprising in making way. (This Darwinian observation is hardly academic.) New maps of human knowledge are being drawn up, new curricular vehicles are being designed, new territory in the way of 'liberal-professional,' 'liberal-technological' options are being charted. This is, roughly speaking, the path of the 'new' liberal arts. Here the enterprise, to switch metaphors, is more architectural than archeological. Here, perforce, tradition gives way to innovation.

Even if this path is not the one chosen for the humanities in every institutional setting, the computer remains to be dealt with at the crossroads — as an important phenomenon to be
understood and a powerful tool to be utilized. It surely behooves us to find ways to involve humanists in its use and management, to the benefit of the humanities as well as the liberal arts generally.

Whichever course the humanities take in whatever institutional setting, the matter of how the computer can be mastered to serve humanistic as well as other liberal-artful ends requires special attention, because the institutional obstacles -- the combined ideological, political-economic, and logistical obstacles -- to embracing the computer in the humanities are at least apparently greater than in any of the other liberal arts (to whose quantitative and data-dense dimensions the computer is so obviously well adapted).

1.3. The College of Humanities and Social Sciences at Carnegie-Mellon

The College of Humanities and Social Sciences at Carnegie-Mellon University is a model of innovation in the liberal arts. The larger institutional setting in which the college has developed its liberal educational mission reflects the exigencies, challenges, and resources of our wider technological society. The special opportunities and inspiration for innovation in the liberal arts are easily understood in terms of the distinctive comparative advantages of Carnegie-Mellon University -- its nationally reknown schools of science, engineering, public policy, and management. The institutional setting has been conducive to the development of a liberal arts curriculum expressly sensitive to the needs of students living in intimate proximity with state-of-the-art science and engineering and their attendant social issues.

Carnegie-Mellon is a natural setting for the evolution of a new liberal arts agenda, incorporating traditional liberal educational values and humanistic literacy with the technological literacy required to negotiate our technological world. A place where the classical technological imperative, Know thyself--know thy tool, and technologies for the direction of the mind can be brought to bear on the tendentious imperative of modern technology in its more worldly and servile guises, If it can be done, it will be, for better or worse. Technologies for the direction of the mind, from the broader range of the liberal arts, presumably direct for the better.

The College of Humanities and Social Sciences has pioneered creative and manifestly successful experiments in the liberal arts on three related fronts:

• The Core Curriculum
• The Liberal–Professional Connection

• The Computer Connection

The Core Curriculum. Over the last five years the College of Humanities and Social Sciences has developed a liberal arts core curriculum consisting of required courses in the following interrelated "cluster" areas:

• Fundamental Methods and Skills. These include skills with natural language as well as the artificial languages of formal logic, mathematics, and computer programming; skills of writing, logical analysis, ethical reasoning, policy analysis, historical explanation, general problem solving, and quantitative analysis.

• Humanistic and Social Values. Philosphic, historical, and literary perspectives on the justification, evolution, and expression of the social values and cultural norms embedded in our world views and social institutions.

• Social, Political, and Economic Systems. Studies of the decision-making, information-processing, and problem-solving methods and processes of American institutions from the perspectives of the social and behavioral sciences.

• Language, Culture, and the Arts. Selected sequences of three courses in foreign language and literature, literary genres, topics and landmark works in a cultural period, or the fine arts.

• Science and Technology. Selected sequences of two courses in natural science or technology.

There is explicit emphasis in the design and teaching of the core curriculum on 'horizontal' integration across the fundamental analytic methods (both qualitative and quantitative) and conceptual frameworks of the liberal arts, on the one hand, and on the potential for 'vertical' integration of these fundamental tools and frameworks as students progress through more specialized study in the upper division courses in their respective disciplines and professional sub-fields.

The Liberal–Professional Connection. The skills, knowledge, and understanding promoted by the core curriculum are presumably prerequisite to the intelligent choice and pursuit of any program of professional or graduate study. But the College of Humanities and Social Sciences operates on the further assumption that high-quality liberal and professional education are compatible and complementary within the undergraduate years, that there exists an educational strategy that will support both disciplinary studies in the liberal arts and professional
concentrations in the management sciences, public policy fields, information systems, and technical and professional writing.

Rather than demoting liberal learning in favor of professional studies, this strategy is to strengthen and insist upon their connection precisely where it might otherwise be ignored, among professionally-minded students. The necessity of liberal arts tools and perspectives is perhaps best appreciated where explicit applications can be made to the broader issues that any professional must address, but in the motivational context of the students' own professional agendas.

Departmental majors and professional concentrations are designed so that any student's program of study can readily accommodate both. Students who wish a more traditional academic education can have it and even add to their breadth by taking advantage of the many double-major options, while profession-bound students receive a rigorous complement of basic liberal arts training through the core and background in at least one of the liberal arts.

Basic quantitative and computer literacy, necessary if only to make intelligent choices among today's professional options that require computing and quantitative skills, are provided in the core. Additional quantitative or computer training needed for professional or graduate work are provided by courses tailored to the students' respective concentrations.

Edward Fiske, in The New York Times Selective Guide to Colleges 1982–83, asserts that our "faculty and administration have done perhaps the most original thinking of any American university in pursuing the twin goals of liberal–professional education" (p. 71).

The Computer Connection. Original thinking and innovation have also marked the efforts of faculty in the college to integrate computer applications into the core curriculum, both as a powerful learning aid and as a tool for facilitating conceptual problem-solving and data analysis. The first and most important step that most students in the liberal arts will take towards computer literacy is in the use of the computer as a learning aid and as a tool in writing, communication, and various analytic tasks.

Students in Humanities and Social Sciences first encounter humanistic computer applications in the Philosophic Methods and Social Values core course in their very first semester. This is a decidedly unexpected but appropriate setting for their first encounter, because questions about the utility of artificial languages, computer-aided learning, and other aspects of their
A package of eight computer-assisted instruction programs have been designed for this course to teach the elements and concepts of formal logic and their application to various analytic-philosophic tasks, from the analysis of natural-language arguments to the formulation of precise and consistent normative principles underlying moral arguments and social policy disputes. Some of the programs provide basic instruction and drill-and-practice routines, but others guide the students in difficult and interesting tasks in strategic reasoning, conceptual analysis, and discovery that are neither trivial nor routine.

Besides allowing the students to master the artificial language of formal logic and its applications in philosophic analysis in short order, the programs naturally stir the students' curiosity about 'artificial intelligence' and how the computer can be 'taught' to do so easily what they often must work very hard to learn to do. Their experience with computer-interaction, the benign learning environment that it can provide, and the additional access it affords to other students and their instructors through computer mail and linking mechanisms, impress the students with the potential benefits of both the computer and a computing environment. (The computer programs receive high student evaluations and are the most popular feature of the philosophy course, in spite of the fact that most students are shy of both computer-interaction and formal logic upon entry.)

It is difficult in an entry-level history course to give the students the opportunity and means to deal with both the raw data and the actual construction of historical inference and explanation. In the Origins of the Modern World course, taken in the second semester of the freshman year, the computer allows the students to go beyond the usual second-hand textbook exposition of the products of historical inference, to become engaged in the actual process, by analyzing a substantial set of historical data.

For a five-week period in the course, the students use the computer to analyze the most portentous collection of public opinion data on the complaints of a broad spectrum of French society (the cahiers de doleances) in order to generate and test hypotheses about the causes of the French Revolution. This computer-based exercise acquaints the students first-hand with the minutiae, difficulty, and methods of historical explanation, on the one hand, and, on the other, demonstrates the power of the computer as a tool for humanistic inquiry, namely, how, in Frederick Rudolph's words, the computer "allows the historian to think with 'enormous new efficiency'" [The New Liberal Arts, p. 62]. Again, the value of the computer-based learning experience is two-fold: it facilitates the learning and execution of an important analytic-
intellectual task, and thereby motivates computer literacy.

While computer literacy may consist, first and finally, in one's ability to negotiate its applications to the learning and execution of intellectually challenging tasks, one of its important dimensions is understanding, in principle and on some level of programmatic detail, how computers operate and can be made to do what they do. In the first semester of the freshman year the students take the Introduction to Computer Programming core course. Based on a mastery-learning model, the course covers generalizable basics of problem analysis, algorithm development, program writing and de-bugging, and documentation, in the Pascal language. (It should be noted that through collaboration of the philosophy, writing, and computing core course coordinators, programming exercises will be designed for the computing course that are analogous to the program structure of some of the heuristic programs proposed for development in sections 3.1 and 3.6.)

These three courses provide fair exposure to the basic operations and broad applications of computers in the very first year of the core curriculum. We propose to build upon this foundation, to design and implement a rich computing environment in the liberal arts that will support the continued development of computer applications in upper-division courses, thereby continue to enhance computer literacy among both faculty and students, facilitate the quantitative literacy to which the computer is so well adapted, but also promote imaginative computer applications to intellectually important tasks and educational goals in the traditional humanities. Perhaps the most compelling challenge in developing powerful and benign uses of the computer in the new liberal arts is to demonstrate how its use and understanding can enhance humanistic inquiry, as well as the more quantitative dimensions of liberal learning.
2. A Proposal: Dedicated Computing Centers in the Liberal Arts

2.1. The Requirements of Computer Literacy in the Liberal Arts

Literacy is essential to being educated. Narrowly defined, it consists in the ability to read and use a natural language. More broadly, it entails an articulate familiarity with the salient literary heritage of a some community or culture. More broadly yet, literacy consists in the ability to handle some basic intellectual tools or body of knowledge intelligently, competently, appropriately, with comfortable familiarity, short of mastery or scholarly expertise.

The liberal arts promote literacy of various sorts — humanistic, quantitative, scientific-technological — and always have. In the so-called computer age, computer literacy is an undeniably important — and new — liberal educational goal.

Computer literacy is not equivalent to programming ability, but demands (at one end of the spectrum) being conversant with the social-ethical implications of computer technology (as computer "mischief" and crime widely attest). Computer literacy, like any other, is not then neatly separable from other educational goals. Computer programming courses per se hardly begin to address the needs of computer literacy, and often may not even be the best first step in that direction. The use and understanding of computers, for liberal educational purposes, demands attention to their social, conceptual, and educational environments and the diverse ends to which computers are appropriately employed.

We might distinguish the dimensions of computer literacy roughly as follows:

- **Use of Computer Software: Computer-Based Tools.** The ability to use available computer packages and tools will be the ultimate and minimal objective of many if not most liberal arts students: editors, text-formatters, electronic mail, computer-aided instructional programs, statistical packages, data base management systems, simulation programs, etc.

- **Use of Computer Facilities: Hardware and System Operations.** The use of computer tools presupposes the ability to negotiate the operating system(s) and peripheral hardware of whatever available computer installation, its communication and networking facilities. This is by no means a trivial component of computer access and literacy, and is a major stumbling block for many students (and faculty) who are not properly initiated or advised.

- **Computer Programming.** The skills and knowledge to program a computer to perform some real-world task are manifold in dimension and level, and include: knowing some programming language, facility with same, problem/task definition, structural program design, algorithm design, de-bugging, perspicuous program documentation, and production of suitable user documentation. Basic computer literacy would perhaps include enough acquaintance with programming in some high-level language to understand the enterprise and to write a program for one's own use.
or exercise — and to know what was required in the way of knowledge and skill for more ambitious applications, how and where to acquire it, as well as some understanding of design concepts and constraints, the difficulties and importance of perspicuous documentation. Basic literacy surely would not include a working knowledge of machine language. But the appropriate standard of programming knowledge is no doubt itself arguable and would vary over specific educational contexts and objectives. For many liberal educational purposes, actual programming skill itself may be arguably unnecessary.

- **Computer Science.** Understanding what computer systems are in principle, what they can or cannot do, is also a multi-dimensional, multi-level and highly arguable matter, different notions of which could be conveyed, variously, in a good programming course, certain courses in mathematical logic and automata theory, in the philosophy of mind, systems science, cognitive psychology, mechanical engineering, as well as computer science proper . . . depending on what type and level of purely conceptual, or applied, or systems-analytic understanding one wanted to promote.

- **Social-Ethical Dimensions of the Use and Impact of Computer Technology.** Surely we want liberally educated people to have some sense of these myriad issues as part of their understanding of what computers and their uses are all about. (Computer ethics enters at least tacitly with one’s first introduction to security devices like passwords.) But these issues can hardly be addressed by people who are illiterate regarding the operation, uses, and workings of computer systems and tools — and being well-read on these matters would not suffice for literacy.

Standards of literacy are surely arguable here, but in addressing the social implications of computer technology liberally educated people — humanists especially — will want some measure of acquaintance with the other, more technical dimensions of computer literacy. One aim of our proposal is to create a model environment where computer literacy is made readily accessible so that these issues can be intelligently and concretely addressed — so that standards of computer literacy for the liberal arts can reasonably evolve in the liberal arts.

The relevant level of computer literacy can neither be gained nor intelligently debated as an issue from an armchair (even one with a computer console at hand). Computer literacy is a social–educational enterprise, and the development of standards of literacy is a cooperative, communitarian concern. Experience with and within a computing environment is wanted for the definition and evolution of reasonable standards of computer literacy for and by the liberal arts community.

Since the setting of computer literacy standards is itself a liberal educational as well as technical issue, it seems essential that liberal arts colleges and faculties take some initiative in their development.

One problem is that most computing environments are firmly centered within and dominated
by the scientific–technological community. A computing facility dedicated to liberal arts applications would best generate initiative in the liberal arts to develop appropriate standards of computer literacy, as well as instruments and curricula to promote it. In particular, it would facilitate one essential condition for the development of any well integrated program of computer literacy in the liberal arts college: faculty participation and development. The informed forecast is that within five years students coming to liberal arts colleges will be more computer–literate than the general faculty [Cf. Arthur Luehrmann, "Computer Literacy," EDUCOM 16:4, 1982, 15–17]. Unless faculty re–tool to address this development, their illiteracy will prove as embarrassing as it would be ironic. And the power and credibility of liberal arts education will suffer by comparison with the computer–endowed technical fields.

The promotion of computer literacy in the liberal arts must begin with the faculty. Liberal arts faculty should of course show some leadership in setting standards and goals for computer literacy. And one function of a computing facility dedicated to liberal arts applications would be to facilitate computer literacy among the general faculty, especially those in the humanities who should be specially concerned with the ethical, social, and educational issues here.

2.2. Computer Applications in the Liberal Arts: Strategy

Probably the least effective strategy for promoting computer literacy in the liberal arts would be simply to throw students (or faculty) into programming courses, especially ones tailored by and for the technical community.

On the other hand, the most persuasive argument to be made for the importance of computer literacy for the unitiated is on the basis of compelling experience, experience with highly accessible, practical, intellectually interesting applications in a benign and supportive computing environment, and, in the case of students, on the basis of faculty enthusiasm and example.

A corollary: arguing for the importance of computer literacy on the basis of the mechanical data–crunching tasks and drill–and–practice routines that computers perform so well is not to make the most exciting case either.

The optimal case can be made on the basis of experience with intellectually engaging computer applications, and priority should be given to promoting the development of such applications in the liberal arts -- and, again, in the humanities especially. The computer can be used to facilitate the mere manipulation of data, words, numbers. And it can be used to model and guide the reasoning and discovery processes we must employ to build and use
arguments and interpretations with those data, words, numbers. The state of the art of computer-aided instruction and inquiry, especially in the humanities, is at a very prosaic level: number crunching, word processing, drill and practice routines. Helpful and powerful as these applications can be, intellectually adventuresome advances are wanted. (Examples of the possibilities now within our grasp are given in section 4 on pilot project proposals; two current examples, in philosophy and history, were described briefly in section 1.3.)

One obstacle to individual faculty enterprise is the difficulty and cost involved in the development of even elementary computer-aided packages. Very few faculty can afford the trade-offs in time and recognition taken from standard research to design and implement a program and its curriculum, let alone to gain the technical facility and saavy to do it well by themselves. Young faculty, who are most likely to be amenable to innovative educational enterprise, are usually least able to risk the time-sink required to master the computer medium.

Most faculty lack not only time (or incentive for taking time), but also access to technical support staff to help in programming and peer collaboration and review to help motivate and refine curriculum. In most liberal arts professions and institutions there exists no infrastructure, no support and reward structure, as there does for doing standard research.

The production schedule for the development of any computer-based curricular package would typically involve a year for research and development of the prototype program, curriculum, and user documentation; a year for initial implementation and internal evaluation; a year for revision and fine-tuning and, possibly, exportation for peer review and outside evaluation. Added effort may be required to render the package transportable to other computer systems or curricular contexts. Five years overall for ambitious packages is not unusual. While recourse to micro-computer systems may facilitate or obviate the exportation effort, the R&D and evaluation labors can still swallow two years if a person is not yet up to speed in micro-computing and courseware design. The personal investment required is high, and the professional rewards uncertain. For the unitiated and prudent, the prospect is good cause for pause.

What is needed is a computing facility that provides not only hardware dedicated to the liberal arts constituency but the collegial infrastructure, technical support staff, and institutional incentives to promote experimental educational enterprise with the computer in the liberal arts.
2.3. The Requirements of a Computing Facility in the Liberal Arts

Any computing facility will have the following components:

- **Computer Hardware.** Some central processing and memory unit, a computer, is obviously required.

- **System Software.** In addition to an operating system, the normal software components will be programming languages, an editor, electronic mail system, document production systems.

- **Peripheral Hardware.** Computer terminals, printing devices.

- **Technical Support Personnel.** The Task Force for the Future of Computing at CMU, headed by Allen Newell, emphasized one of the elementary requisites of any effective computing facility in its preliminary report (CMU Focus Supplement, March, 1982): "A collection of hardware and software requires human support to weld them into a usable computational facility ... the basic ingredient of the support system remains what it has always been — a well-managed human organization."

Even in well endowed computing environments, rich in the requisite hardware, system software, and computational center staff, liberal arts faculty often do not have access to technical support staff who are conversant with or dedicated to their needs. Systems analysts and experienced programmers who could trouble-shoot, provide program design expertise, tutor faculty in computing know-how, guide projects through design, development, documentation, conversion for exportation or micro-computers, and generally be available for consultation on a regular and continuing basis would greatly accelerate the assimilation of computer literacy and the development of sophisticated courseware by liberal arts faculty. A reasonable division of labor would be to have technical staff to assume primary responsibility for the software and faculty dedicate themselves to the curriculum, pedagogical niceties, and course integration of the courseware. Of course, over time faculty would become more computer-competent and the technical support staff more familiar with the curricular and intellectual agendas of the areas of computer applications. Collectively, this developing interdisciplinary community would provide the combination of technical expertise, collegial exchange, peer review, collective imagination and motivational synergy required for the advancement of, and professional advancement within, any serious intellectual art.

The developing infrastructure, the human support system would collectively provide three allied and cross-fertilizing dimensions of expertise: technical, intellectual, and pedagogical. A well developed computing facility or center dedicated to the liberal arts should promote two additional areas of support and cumulative expertise: evaluation and dissemination. The key to these developments is dedication, the dedication of technical staff, faculty time and expertise as well as machinery, to supplant the highly inefficient and frustrating conditions of willy-nilly
user consultation and comparative isolation under which computer applications must currently be pursued. Such dedication will undoubtedly entail some re-allocation of institutional resources and rewards to provide incentives for faculty to offset the opportunity costs or perceived risks to professional advancement. It will undoubtedly require outside support to offset the start-up costs of obtaining technical staff and equipment beyond the margins of most college or departmental budgets.

The present lack of dedicated resources and technical staff involves faculty in the manifestly inefficient task of having to re-invent the wheel and the frustration of knowing that this is what they're doing, that someone out there could provide a better computational vehicle and get them up to speed in a fraction of the time, allowing them more time and energy to do what they do best. Even if one sees the computer revolution in the liberal arts as an inevitability, the pace and manner of individual enterprise represents an inefficient deployment of faculty resources and discouraging prospects for would-be entrepreneurs.
3. Computer Applications in the Liberal Arts

The following sections contain descriptions of the sorts of computer applications that are presently envisioned by faculty in the various liberal arts departments and programs at Carnegie-Mellon. [I will not be reading this section in my address, and will refer to the philosophy projects only briefly for illustration. I am not in a position to answer questions about the projects reported afoot in other departments. I provide this section for your information and future reference, for any ideas it may give your own faculty at St. Cloud regarding what is possible in the development of educational software in various of the liberal arts.]

3.1. Philosophy

3.1.1. Exporting Computer-Based Logic

Preston Covey and a computing consultant funded by a FIPSE grant have developed a package of computer-assisted instruction programs at Carnegie-Mellon University to teach first-order logic and to explore its applications to the analysis of relatively sophisticated (in our case, philosophic) arguments. The package is called ANALYTICS and presently consists of the following seven programs of three types:

Question-and-Answer Instructional Programs in Sentential Logic


VALID: Seven lessons on the truth-functional proof of validity and intuitive explanations of the basic rules of inference for sentential logic.

Drill-and-Practice Programs in Symbolization and Truth-Value Analysis

SYMBOL: Generates symbolization exercises and (when required) answers on selected levels of difficulty with various combinations of sentential connectives. Students may also set the parameters to have the program generate exercises of any complexity of their own choosing. Generates sentence schemas with only the connectives themselves in English. Employs a variety of connectives (like 'however,' 'unless,' 'just in case').

SYMBO2: Otherwise like SYMBOL but generates actual English sentences from a library of atomic sentences created by the instructor.

TRUTH: Generates sentence schemas with English connectives like SYMBOL with truth-value
assignments for the sentential variables. Asks the student to analyze the truth-value of a
molecular sentence of that form given the assigned truth-values. Leads the student through the
truth-functional analysis and provides hints (or answers) if requested.

Argument-Analysis Programs With Proof-Checker

RECON: Provides English argument texts from libraries of stored arguments for the student
to reconstruct in valid symbolic form. Asks the student to assign constants to the atomic
sentences of the argument, to identify and symbolize the stated premises and conclusion of the
argument, to supply any 'missing' premise(s) needed to make the argument valid, and then to
prove the argument valid by deriving the conclusion. The program provides hints in all phases
of argument reconstruction as well as an English translation, on request, of any lines of the
argument or derivation so that the student can think about the content as well as the logical
(symbolized) form of the argument simultaneously (and, as presented on the screen, side-by-
side). The hints also guide the student in the construction of plausible 'missing' premises. So,
the program facilitates—and reinforces—the need to play form (the constraint of formal
validity) off against content (and non-formal constraints like plausibility) in the analytic–
intuitive search for 'missing' or operative but unstated assumptions of an argument. The
program's proof-checker monitor's each step of the derivation of an arguments conclusion for
well-formedness and validity.

ARGUE: Provides English argument texts and word problems for analysis from libraries of
stored problems, but unlike RECON also handles arguments formalizable in quantificational
logic (with identity) and operates in 'free-form' mode in which the student can enter and
manipulate his own symbolized argument and English constant assignments. ARGUE can then
provide an English translation at any point of a derivation, as with stored problems. The
program can be used for purely formal derivational work as well as exercise in reconstructing
English arguments with their underlying principles or 'hidden' assumptions. Besides providing
hints and immediate error messages, the program greatly facilitates the mere manipulation of
symbolic formulae in derivational work and provides clear formatting in the display of
conditional proofs.

We employ these programs in a required freshman core curriculum course to teach first-order
formal logic, with applications to argument analysis, in just over half a semester. The class
average on standard examinations has improved one grade level since the introduction of the
programs to the course; the programs consistently poll as the most valuable element of the
course; and the ARGUE program in particular receives a very respectable 4.2 average on the
student rating scale where 5 is the highest rating for effectiveness. This, in spite of the fact that most of our students are shy of both computers and formalism upon entry to the course.

The programs utilize the notational and natural deduction system found in the most popular elementary logic texts (such as Copi and Kahane) and have their greatest utility in introductory logic courses that stress the formalization of English arguments (as opposed to more mathematically inclined courses or ones favoring a Fitch-style natural deduction system). Thus they would be well applied in the majority of introductory logic courses, especially ones that wish to teach a fair complement of formal logic in minimal time in order to include course segments on informal or inductive logic. (The philosophical agenda and utility of the ARGUE program, in particular, is laid out with extended illustration in Covey's "Formal Logic and Philosophic Analysis," Teaching Philosophy, Vol. 4, Nos.3/4. The rationale for the importance of formal logic and symbolic artifice in the teaching of so-called 'logical' thinking is presented in his "Logic and Liberal Learning," op. cit.)

The problem is access and transportability. The now widely acknowledged utility of these programs cannot be enjoyed by any but those who have access to large mainframes dedicated to educational use. One useful project would be to convert the programs to run on smaller and a greater variety of mainframe computers. Another would be to redesign them to run on micro-computers like the IBM. This is an example of the sort of dissemination work that could be done under the support of the proposed center, taking advantage of already developed and field-proven courseware.

3.1.2. Computer-Based Philosophic Analysis and Inquiry

Basic to philosophical inquiry into values and fundamental principles is the dialectical process of abstracting general principles and testing them against the plausibility of their consequences and their consistency of fit with other principles and values. A similar procedure informs the effort to clarify and test the consistency of principles underlying the law and public policy, the preference rankings that constitute prima facie evidence of the public's interests, and the perceptions (for example, of risk) that inform those preferences in turn. Classroom evidence and psychological research show that people in general have a devil of a time maintaining consistency across sets of cases that are relevantly similar in some respects but disanalogous in others. While absolute consistency in one's principles, preferences or priorities is perhaps beyond any of us, one fundamental objective of philosophic training is to help students become more skillful at articulating principles and arguments, thereby explicating the grounds of their value judgments, and spotting and conscientiously adjusting for manifest inconsistencies.
One practical problem is leading individual students through a sufficient complex of cases and tracking their judgments. Another problem is that inconsistencies in one’s operative principles, assumptions, priorities, or judgments over a range of cases (usually over time) are difficult to spot; usually there is no scrutinizing agent (as in the public evolution of the law) to point them out. The intellectual ability to negotiate the straits of the Scylla of inconsistency and the Charybdis of implausible consequences is absolutely fundamental to value analysis and inquiry. Yet it is practically impossible to put students through any rigorously scrutinized practice in this task.

The computer, however, has the memory and patience to track such a process. Moreover, it facilitates the recording and comparison of judgments and rankings both over time for a given individual and across individuals (a mini 'moral community', as it were). The 'smarts' required for the computer to appropriately inform a student of his own and others responses and guide him through considered revision and adjustment need only be supplied by the same thoughtfulness and pedagogical intuition a teacher would employ to plan a trenchant Socratic discussion in class. Such a program could be menu–driven or even organized around multiple–choice nodes with branchings and loopings. Undoubtedly, other software technologies (as are used to track and adjust the logic of peoples' priorities) could be employed to imaginative advantage.

The basic format of such programs could be supplied with a wide variety of curricula relating to different topical areas and levels of value and policy disputes. An obvious area of application would be risk perception, analysis, and management. Here the pedagogy of the program would have a wealth of psychological study to draw on. Writing the curricula for such programs would not be a trivial task, but we have already various technologies for designing the programming. This is a significant diagnostic and critical inquiry heuristic well adapted to the computer's special capacities and well within our grasp.

A program that operated on the level of complexity represented by the dialectical reasoning section of the LSAT, supplied with a modest docket of cases, would be a powerful tool for use in any context of value analysis—especially if the curriculum's subject matter were written to parallel the topics and issues covered in the course. The program type would have as many applications as there were contexts of value and policy dispute.

Similar adaptability obtains with the DRAFT program described below in section 3.6. DRAFT is an EMACS–style text editor that is being designed to interface with a writing instruction module. The instruction module can be provided with different heuristics for
guiding the composition of different sorts of papers (under different sorts of disciplinary constraints, or according to different strategies or inquisitorial procedures). An instruction module could be developed to guide a student through the actual composition of a 'philosophy' paper or a value-analytic essay. Interdisciplinary collaboration between our philosophers and rhetoricians would assure such adaptation, as well as the use of different instructional modules across courses to assure that the reasoning heuristics taught in one course were reinforced by the way in other courses. Computer-modular instruction is one obvious way to effect this kind of cross-curricular reinforcement.

These are just two examples of the way the computer could be readily mobilized to bolster training in relatively sophisticated tasks of philosophic analysis in which students are rarely or only minimally exercised in traditional learning. (Concrete, extended illustration of the reasoning tasks in question in value inquiry and analogies to legal and scientific reasoning are provided in Covey's "Formal Logic and Philosophic Analysis," op. cit.)

It should be noted that the curriculum of the proposed value-analytic programs could be coordinated with the problem files of the argument analysis program described above in order to put students' assumptions and principles under both dialectical duress and rigorous logical test, respectively. The curriculum of either type of program could be designed for any level of difficulty in entry-level or upper division courses, and different curricula could be ordered according to degree of difficulty (as is indeed done in the case of the logic programs). A course-management program would, ideally, guide a student's progress through these rising hurdles.

Other straightforward computer applications exist for the posing and adjudication of conceptual dilemmas. One powerful dilemma drawn from game theory, the so-called 'Prisoner's Dilemma,' is eminently suited to computer interplay and a powerful model for teaching the fundamentals of social contract theory and the rationale for social/moral norms. Here are three specific ideas we are pursuing:

1. The DIALECTIC package. Fundamental to philosophic analysis and inquiry are techniques and skills in abstracting general principles from judgments about particular cases, testing those principles against limiting cases and competing principles, thereby assessing one's putative principles for plausibility and consistency within some minimal constraints of what's called 'reflective equilibrium.'

Ordinarily, it is not possible to provide much practice or guidance in these procedures. Even in cleverly designed, hard-coded tutorial programs, moving through a network of multiple-choice nodes, one could significantly enhance a student's working understanding of the complexity of philosophic issues and the procedural and probative norms of philosophic inquiry.
Helpful analogies and contrasts among the procedures of philosophic analysis generally, ethics, law, and science (hypothesis generation and testing) could be illustrated against a wealth of computer-structured experience in dialectical inquiry, *nee* Socratic method.

A program that elaborated the kind of exercise contained in the analytical reasoning section of the LSAT, a minimal and easily mechanized model of dialectical reasoning, would be a powerful pedagogical aid in any number of philosophy courses. A variety of topical issues and curricula could be written for or laid over the same logical machinery—much as different problem sets presently employ the same proof-checking machinery in the *RECON* and *ARGUE* programs. Such computer modules could be integrated into the core writing course or the pre-writing phase of composition instruction, as well as into a variety of philosophy courses.

2. The *DILEMMA* package. Dilemmas of various sorts motivate, animate, and boggle the philosophic enterprise. Dilemmas are best appreciated if one is forced into them by routes of one's own choosing, and if one is forced to try to find one's own way out of them.

A package of exercises, elementary in their programming (like *DIALECTIC*) if not in their curricular design, could immerse students first-hand in the standard dilemmas that are the impetus and bane of many important positions and strategems in philosophy. Class and textbook discussions of classic philosophic issues and positions, as well as paper assignments, are bound to be better informed, less facile, and analytically more acute against the background of such computer-based rehearsal in following the consequences of one's philosophic preferences into the horns of perennial dilemma. It is in the nature of such dilemmas that they follow upon any number of plausible choices of position; this is an issue worth forcing in a student's philosophic development.

Again, menu-driven inquiry in an interactive environment, while elementary, would be a significant improvement over passive contemplation of the set pieces of textbooks and lectures.

3. *SOCIAL CONTRACT.* This program would generate and monitor Prisoner's Dilemma games, played respectively against the computer analogues of variously 'rational,' self-interested opponents.

Variations in the 'rationality' or 'morality' of the opponent could be effected to illustrate the problem of generating mutually agreeable (moral, legal, or other) rules in various two-person models of the social contract theorist's 'original position.' This would provide more elaborate and first-hand exercise than could a textbook or lecture with the problem of defining the constraints under which the imposition of various rules would be 'rationally' agreeable—an exercise in one important model of rational rule-generation or moral theorizing.

It would, at minimum, force an appreciation of the game-theoretic dilemma that is often invoked to motivate social contract theory: students are otherwise wont to seek an illusory solution by leaping between its horns. This computer module would be used in the core course as well as courses in normative theory and rational choice theory.
N-person gaming scenarios would be developed on the model of classroom experiments in collective choice in PD situations that have been tried and published in both the philosophic and game-theoretic literature.
3.2. Psychology

In the Psychology Department we currently require majors to take two courses in research methodology. Methods courses are available in the areas of cognitive, social-personality, and developmental psychology. We anticipate integrating computer based learning experiences in each of these courses, beginning with the social-personality research methods course taught by Margaret Clark.

Currently about one fourth of the research methods course is devoted to survey techniques and three quarters to experimental techniques. Students attend regular lectures and take a mid-term and final exam. In addition, students plan one original survey and one original experiment, carry them out, analyze data from those projects and write final papers on them. At present the only contact students have with the computer in this, as well as in the other courses, is for purposes of data analysis. They are required to learn to analyze their data both "by hand" and on the computer utilizing statistical packages.

While there are no major problems with this structure and it will be kept basically intact, we feel that students' learning could be enhanced by exposing them to some additional computer based experiences in the context of this course. Furthermore, having additional requirements seems reasonable since students in this course receive extra credit for their "laboratory" experiences.

We have three goals in incorporating computer based learning experiences into the course. Each of the proposed projects designed to meet those goals are briefly outlined below.

1. Providing additional experiences in dealing with survey data. Past experience demonstrates that in the course of half a semester students can conduct only a very simple survey and collect only a small amount of data. This means that our students obtain no "hands-on" experience dealing with a large data base. Yet, in the "real world," surveys commonly generate very large data sets. Therefore, we propose assembling several sets of actual data on social-personality questions in a computer library as well as a set of data from a continuing longitudinal study on student attitudes which would actually be conducted by students enrolled in the class each semester in addition to their own survey. We also propose locating and developing the appropriate software with which to analyze this data.

Once the data sets and software are "in place" students will be given assignments involving testing hypotheses using this resource. These assignments would follow the analyses they will have already performed on their own data sets and expose them to more complex data analyses and to thinking about more complex issues than is now feasible. At present the question of
how to deal with such material can only be lectured about in class. This is clearly not the optimal way to learn such material.

2. **Teaching students about new techniques for conducting experimental studies.** Following the "survey" portion of the course, students learn to conduct experiments. Much is learned about this through class lectures, practice in designing manipulations and measures, as well as through actually conducting a study. However, it is becoming increasingly obvious that once an experiment is designed the computer often, but not always, can provide the most efficient and controlled way of presenting stimuli and collecting data. For example, stimuli commonly used in social-personality psychology, such as descriptions of other people or communications from confederates, can be easily presented on a terminal, and data such as ratings on scales, written responses to another, and reaction times, can be easily collected on the computer as well. We propose developing sample studies utilizing the computer to conduct social/personality experiments, as well as specific assignments and materials allowing students to develop their own computer-based manipulations and measures.

3. **Providing students with simulated results from experimental studies.** As noted above, in half a semester students can only conduct a simple survey and collect a limited amount of data. The same problem applies to the experimental study they conduct as well. Thus, it would be useful for students to have data to analyze and interpret which was generated in reaction to manipulations and measures used in their own study and in the context of designs other than the one they used. Analyzing and thinking about experimental data is most productive when that data was generated in reaction to students' own manipulations and measures. Thus we proposed developing a computer program which will accept a student's proposed manipulations, measures and design (within some specified restraints) and generate data which will vary in how easily it can be analyzed and interpreted. Once such a program is developed students can practice designing, analyzing data, and interpreting results from studies other than the one they were actually able to carry out. Furthermore, in this way they can actually "see" what the typical effects which variations in design (e.g., between subjects vs. within subjects designs), types of measures (e.g., dichotomous vs. nondichotomous measures), and types of manipulations typically have on their data. It will also give students whose own study "worked" experience in figuring out what went wrong when a study does not work, and students who find no differences in their studies experience in interpreting differences which may not be exactly as they expected.
3.3. Social Sciences

Background: Carnegie-Mellon's Social Sciences Department is distinctive in several ways. The department integrates empirical skills and theoretical perspectives from a variety of disciplines. Faculty educated in decision theory, economics, political science, psychology, sociology and organizational theory promote a multi-faceted view of important political, economic and social problems. The department's programs combine empirically-based theories of organizations and decision making with their applications in current policy issues. Mathematics, statistics and computer science also serve as prerequisites for Bachelor of Science degrees offered by the department and for the undergraduate professional degrees in Public Policy and Management and Information Systems.

Project Proposal: The Department of Social Science is in a unique position to develop and implement upper division courses that utilize computing. The faculty is much more sophisticated than most Social Science faculties in computer usage. Faculty usage levels are high and growing in both research and teaching. We have experience with computer usage in several courses.

The proposed project for Social Science within the larger proposal for the College consists of developing and implementing four computing oriented upper division courses. The courses are: (1) Introduction to Models in the Social Sciences; (2) Empirical Research Methods; (3) Organizational Decision Making; and (4) Non-market Resource Allocation. Each course is described briefly below.

Introduction to Models in the Social Sciences

As part of the department's requirements, all students are required to take a course which introduces them to the application of mathematical models in the social sciences. This course, Introduction to Models in the Social Sciences, acquaints students with broad classes of models (choice, exchange, learning, and diffusion) used in all the social sciences. An important objective of the course is to develop the ability of students to think about social phenomena using abstract models, and to develop basic skills in applying simple mathematical models to social phenomena. The course adopts a problem solving orientation in which students are presented with observations and their task is to formulate their own models (both graphic and algebraic) in order to explain the observation.

In the last year, we have begun to develop computer applications for the course which are designed to increase student's analytic capabilities. We have offered a special section of the course for students with programming interests and skills. In this section, students use the
computer in two ways. First, they are given access to existing computer programs and asked to conduct experiments designed to test propositions about the behavior of the model. Second, they are assigned the task of developing their own computer representations of models introduced in the course. The second sort of activity is particularly useful for computation bound models which otherwise would require students to undertake the relatively laborious task of grinding numbers through equations. The computer frees them from the need for mindless number crunching while at the same time ensuring that they understand the model well enough to represent it as a program. This allows students to explore the implications of the models in ways which would just not be feasible without the use of the computer.

We propose to extend this year's efforts. We need to develop many more examples and problems for this course than we now have. And we need to test these materials in the classroom and modify them. The success of the course requires that the computer actively contribute to student's learning, and the programing component must be carefully integrated in to the learning experience. We propose to:

- Extend the range of models to better reflect the diversity of applications in the social sciences;

- Develop and introduce the computer models of two types to the course. First, a social science equivalent of the engineer's "black box" in which students would be presented with a computer model of a social phenomenon and their task would be to determine the structure of the model solely on the basis of experiments with the input-output behavior of the box. Second, provide students with programs simulating individual and organizational phenomena which give students the opportunity to test alternative structural assumptions by replacing sections of the computer program with their own code.

- Develop exercises and exams that can be given, completed, and graded without any 'hard-copy'.

- Develop a second course which can sharpen student's analytic capabilities by providing a more sophisticated set of models which exploit the particular advantages of computer modeling and simulation.

It would be a mistake in a course of this type to move entirely to computer-based models. One of the very important lessons we want students to learn is what modeling approaches are appropriate for which problems. There are and will continue to be problems that can be solved much more efficiently with a little algebra on the back of an envelope than with a computer program. We want our students to develop good judgements about research approaches.

Empirical Research Methods
In 1982–83 we will begin to require all Social Science majors to take a two-course sequence in Empirical Research Methods. This course will introduce students to a variety of research methods used in the Social Sciences including survey research, elite interviewing, experimental and quasi-experimental design, participant-observation and content analysis. There is some useful application of computing associated with all of these methods.

This course sequence has not yet been designed specifically. We propose to build extensive computer applications into the course from the outset. The course will not teach statistics per se; a two–semester statistics sequence (required of all H&SS students) will be a prerequisite. But students will be taught and will actually participate in all aspects of the research process, including data collection, analysis, interpretation, and presentation. The computer can be used throughout the research process. For example, at the data collection stage, the computer can be used to present survey questions and record the answers of respondents for telephone surveys, to present stimuli to experimental subjects or to serve as a vehicle for communication between experimental subjects. At the analyses and interpretation stage, the computer can be used for complex statistical and textual analyses. Packaged statistical programs like SPSS (Statistical Package for the Social Sciences), SAS (Statistical Analysis System) or BMDP (Bio–Medical Programs: Series P) and textual analyses programs can be adapted to the demands of the course. And finally, at the presentation stage, computer graphic capabilities can be used.

What is especially innovative in what we are proposing is the emphasis on both thorough research training and multiple opportunities for research experience. As envisioned, the course will offer many more opportunities to do research than a conventional "research design" course. However, in order to provide such opportunities, new computer-assisted research exercises need to be developed. Existing sources of exercises, such as the American Political Science Association's SETUPS series, are too elementary in level and too limited in scope. If students are to develop any sophistication in doing research, a more challenging, diverse set of exercises needs to be created.

**Organizational Decision Making**

Organizational Decision Making is an upper–level course which focuses on information processing and decision making in organizations. Pre–requisites for the course include the Department's introductory course on organizations and a course in cognitive psychology.

Organizations are large and complex entities and we rarely have an opportunity to perform experiments on them. An important research tradition in the study of organizations has been based on computer simulation: Cyert and March's 1963 *A behavioral theory of the firm,*
Cohen, March, and Olsen's 1972 *Garbage can model of organizational choice*, and Michael Cohen's current research on the structure of organizations all use computer simulation as a basis. Computer simulations make it possible to explore the implications of assumptions about individuals and variations in organizational structure on the behavior of the organization.

Professor Cohen at the University of Michigan has developed an elaborate software system for modeling organizations. The system enables users to explore a variety of assumptions about organizational behavior and to explore the relationship between the organization's design and its functional effectiveness. For example, within the system it is possible to manipulate incentives to individuals and subunits, the degree of centralization of decision making, and the information available to individuals and subunits and to trace their impact on the the effectiveness of the organization.

We propose to transport this system to CMU, and with Professor Cohen to elaborate the system and to develop new teaching applications.

**Non-Market Resource Allocation**

Several faculty in the Department of Social Science at CMU specialize in research on non-market resource allocation (i.e., budgetary processes and related topics). Much of this research utilizes computer-based models of non-market resource allocation processes. We also teach in this area.

There are currently no useful interactive simulations for teaching budgeting and related topics (e.g., accounting and forecasting). We propose to develop such a simulation based on the budgetary process of municipal governments. A crude flowchart version of such a simulation has already been produced.

In the simulation game, students will play the role of chief financial officer. They will be required to: (1) forecast revenues and expenditures for both budgeting and cash-flow management; (2) instruct Departments in preparing their appropriation requests; (3) use forecasts, requests and other data to produce a balanced budget and submit it to a city council; and (4) manage the budget and cash-flow, taking management actions and recommending legislative actions as required. The simulation will: (1) produce Departmental requests conditional on budget instructions; (2) simulate revenue and expenditure experience; (3) simulate audit experience, (4) provide a stream of contextual information; and (5) politically evaluate the budget officer's performance.
The simulation will be a major part of the course on non-market resource allocation.

Conclusion.

The computer applications in four courses described above will greatly enhance the Department's ability to produce technically literate students. Successful completion of the projects will put us well ahead of the state-of-the-art in Social Science teaching.
3.4. Economics

Background: Carnegie-Mellon has a longstanding record of excellence in the teaching and research of Economics. One of the few small and personalized departments in the field, CMU's Economics Department ranks in the top 20 of over 4000 economics departments at colleges and universities throughout the country. Its rating reflects the outstanding quality of its faculty. Most faculty members of the Economics Department also hold appointments in the University's Graduate School of Industrial Administration, which is listed among the nation's top eight business schools. The Department offers the B.S. in Economics and in Managerial Economics.

CMU's Economics program reflects the economist's need for broad knowledge of the world plus tools for specialized analysis. Through Core courses in the arts, natural sciences, humanities and social sciences, students develop a context for economic analysis. Sophomores take Principles of Economics, an introductory level course which provides an overview of the private enterprise market system and acquaints them with basic concepts, issues and analytic techniques of economics. Requisite courses in calculus and optimization teach quantitative methods used in economic investigation. As juniors, Economics majors pursue specialized problem areas in depth and at the same time gain sophistication in economic reasoning.

Project Description:

Econometrics is a body of statistical methods developed for the study of non-experimental data. A course in econometrics provides students with the opportunity to develop skills required to empirically test predictions of economic theory and to measure the importance of variables that play a central role in economic analysis. Thus, a course in econometrics can play a pivotal role in helping students learn how abstract concepts can be fruitfully used to understand and investigate practical problems.

Econometrics is best learned by studying both theory and applications. Theoretical development provides a set of principles for evaluating the results obtained when various methods are employed to study a body of data. Applications illustrate theoretical procedures and demonstrate the strengths and limitations of various methods.

Applications can usefully be of two types. Many of the problems and pitfalls of data analysis can best be illustrated by investigation of data sets exhibiting certain characteristics. For this type of application, it is useful to design and construct data sets with properties that provide generic illustrations of problems that can arise in data analysis.
The art of using empirical methods to study economic phenomena must ultimately be learned from the investigation of "real world" data. Economic models address a host of issues at the disaggregate level (e.g., the behavior of individuals as consumers and suppliers of labor, the behavior of firms) and at the aggregate level (e.g., the determination of unemployment, inflation, productivity, etc.). Data sets can be developed that permit the study of interesting economic issues and illustrate a variety of econometric procedures. Such data sets must be chosen with care, however, so that the level of complexity of the appropriate economic models and econometric methods are suitable for advanced undergraduates.

At Carnegie-Mellon, Econometrics (73-360) is a required course for undergraduate Economics majors. It is also taken as an elective by students not majoring in Economics. At the present time, each undergraduate instructor of econometrics brings to the course certain applications drawn from his/her own experience. The number and range of examples may increase if the instructor teaches the course in successive years, but an individual instructor does not have the time and resources to undertake construction and selection of data sets to illustrate the range of economic and econometric issues that could fruitfully be explored in applications. Therefore, we propose to undertake the development of data sets for the two types of applications discussed above. An instructor's manual will be prepared that identifies issues that can be studied with these data sets. In addition the manual will document the results obtained when various econometric procedures are employed to analyze these data sets.

Qualitatively different tasks are entailed in developing data sets for the two types of applications discussed above. For the first type of application one essentially works backward using the results one wishes to illustrate to create data that generate those results. Creation and documentation of data sets for this type of application can be completed by a faculty member working one-fourth time for a period of one semester.

Developing data sets for the second type of application is a somewhat more time consuming task. To develop these data sets it will be necessary first to review published empirical results from various specializations within Economics. From this review, applications will be selected that illustrate careful and creative uses of empirical methods to study a variety of interesting economic issues. The desired data sets will then be acquired from authors of published works where this is possible. Where this is not possible, data sets will be compiled from original source materials. This second task can be completed by a faculty member working one-fourth time for one semester and half-time for one summer.

When the data sets have been assembled, they will be placed in a permanent computer library
interactively and complete homework assignments as directed by the instructor. Instructors will be encouraged to add their own data sets to the library.

This project can be completed by a faculty member working one-fourth time for one academic year and full-time for one summer. The task will be undertaken by Professor (........). Professor (........)'s research entails extensive use of econometric methods and he has taught undergraduate econometrics in the past. Required secretarial, keypunching, and computer resources are included in the attached cost estimate.
3.5. History

Background: The C-MU history department has a long record of teaching students not just about history, but how historians work and think. We do this because we are convinced that the skills of the working historian — for example the ability to find and evaluate evidence, to draw inferences from that evidence and to be intensely critical of unsupported generalizations — are common-sense abilities which will have great value in the students' lives and careers even though few will become professional historians themselves.

This long-standing departmental concern is reflected in the three history courses taken by all history majors — the freshman and sophomore history courses in the H&SS core plus the History Workshop, which is described below — and is especially evident in the department's leadership in the emerging field of applied history. At the graduate level we have received national attention for our program to train historians who will use the tools of the profession to work on contemporary policy problems. We also have an undergraduate concentration in Applied History, as well as concentrations in Urban Society, Public Affairs, Social Processes and History of Ideas.

Project Proposal: The undergraduate history major at C-MU begins with two courses in the H&SS core curriculum: Origins of the Modern World, which students take in their freshman year, and The Development of American Society, which they take in their sophomore year. In both these courses the History department carries out its longstanding commitment not just to teach students about history but to teach them to do history. This objective is reflected in a number of specific exercises, of which the ones germane to the present discussion are a computerized research task in each of these two courses. In the freshman course, students work use a dataset based on content analysis of the grievance-lists drawn up in 1789 in France to test hypotheses about the outbreak of the French Revolution which occur in their readings. These skills in the use of "public opinion" data are carried forward and developed in the sophomore course, where students use polling data to explore generalizations which have been offered about postwar American society.

Our objective now is to provide within the upper-division history offerings a set of further computer-oriented skills which enhance the ability of history majors to cope with the technological challenges of the world in which they will function upon graduation. The logical place to build these skills is within an existing framework of courses designed to impart the skills of working historians. Those courses are

1. The History Workshop. This is a course, required of all history majors which develops the skills associated with the "detective" side of the historian's craft. Students become highly skilled at exploiting the resources of libraries and other
repositories, through rather demanding exercises designed to foster resourcefulness. We try to develop skills which will be transferable to work situations outside the academic world, and not just of value to professional historians. The culminating project in the course is a piece of original research in local (i.e., Pittsburgh) history, in which students must utilize real primary sources. At present there is no computer component in this course.

2. Computer Applications in the Humanities. We have long had an elective course under the title Quantitative Methods in History, but until now it has ordinarily been taught by inclusion of undergraduates in our graduate course with the same title. This is no longer a satisfactory arrangement because the graduate course must be devoted mainly to the teaching of elementary statistics, which our undergraduates all now take in the core curriculum. Accordingly, we are experimenting with a new version of this course designed to capitalize on the statistical and programming skills students already have. The objective is to develop those applications of the computer which can be described more as database management than as "number-crunching", not only because these functions are more applicable to historical research, but also because they are more closely analogous than is scientific computing to the computer functions our humanities graduates will meet in industry and government.

3. An Introduction to Applied History. This course exposes students to points of convergence and divergence between historical research and public policy analysis, introduces them to research techniques that have proved successful thus far in that sub-field, encourages them to do applied-historical research on a topic of their choice, and helps them define and create their own distinctive way of doing historical studies that are designed to explicate the dimensions of current social problems.

4. An Introduction to Historical Demography. This would be a new course which has not yet been offered. Historical population studies, however, are at the cutting edge of the profession's research agenda, and we have a new faculty member who is doing research in this area. We would envisage this as, for a number of students, a capstone to several experiences with computer applications in history.

We propose to develop several applications of computer technology which can be utilized in these three courses. Because the three courses are not strictly sequential for all students (e.g., a number of non-history majors enroll in courses 2 and 3), some of these projects may be used in more than one course. The projects would be developed by a team consisting of Professors W. Andrew Achenbaum, Katherine Lynch, David Miller and Michael Weber. Professor Achenbaum has been developing the Introduction to Applied History, Professor Lynch is an historical demographer who would be developing the course in that subject, Professor Miller has been teaching the History Workshop for several years and is developing the new course in Computer Applications, and Professor Weber is an urban historian with experience in the use of quantitative evidence.

We would like to undertake the following projects:
1. **Bibliographic searching**: The ability to search the recent scholarly literature for research on a given topic is one of the skills taught in the History Workshop. Hitherto, students have gone about this task by the conventional methods of visually searching published abstracts, indexes and bibliographies. The C–MU library now has the capability to perform very sophisticated searches of bibliographic databases such as ABC–Clio for historical materials and an number of others for other disciplines. For the most part the library must confine these services to paying customers, such as faculty financed by research grants. We are asking for a modest sum to enable us to introduce undergraduates to the use of these resources in the History Workshop and the Introduction to Applied History.

2. **Data analysis.** In the freshman and sophomore history courses the students already get experience with data which have been preprocessed of application can be for a specific kind of analysis. In subsequent methodological courses we want to move them more and more toward tapping databases which have not been preprocessed. To that end we propose several specific projects:

   a. **Issue-oriented problem sets.** We would like to devise problem sets on foreign policy and social welfare issues for use in the Introduction to Applied History. These exercises would resemble the computer modules on the freshman and sophomore history courses in that they would use data which have been preprocessed for analysis by a statistical package. We would try, however, to include data of several disparate types (e.g. data on level of welfare services as well as public opinion data and demographic data) to allow more sophisticated analysis. We would rely especially on the resources of the Inter-University Consortium for Political and Social Research (ICPSR), of which C–MU is a member, for the raw data from which these problem sets would be drawn.

   b. **Pittsburgh history.** We would like to introduce into the History Workshop an exercise in which students carry out analyses of machine-readable data on Pittsburgh in the nineteenth and twentieth centuries. A good deal of such data already exists. Professor Weber has prepared several samples of demographic data for use in his own research, and other researchers in the Pittsburgh area have similar data which we believe we can obtain for instructional use. The most important single such effort is the University of Pittsburgh’s project to input the nineteenth century census data on individuals. These data are available for the 1850, 1860, 1870 and part of the 1880 censuses. We are asking for support to collect as many as possible of these materials, prepare documentation on them, and build software which makes it relatively easy for student to extract the data items they need to carry out a modest research design. These materials could then be used both in the History Workshop and in Professor Weber’s very popular course in the History of the Pittsburgh Region.

3. **Data collection:** Historical research tends to be data-intensive. Merely getting the data into or out of the computer and keeping track of it while it is there tend to be much more formidable problems than the statistical manipulation of it. It is a major step to move from using the computer to access data in the controlled environment of a well-prepared class exercise to being able to use existing machine-readable archives of research data and/or to create and manage one's own database. Ordinarily that step is not taken before a student is in graduate school, but we hope to take advantage of the core curriculum to enable at least some of our students to
take that step as undergraduates. To that end we would like support for the following projects:

a. **File Building and Maintenance.** Because they all take an introductory programming course, we can train our students to handle the problems of database management efficiently. We can, for example, train them to tailor interactive software for a research project which they design themselves, thereby vastly reducing the drudgery of typing data into the computer and then painstakingly checking it for typographical errors. This kind of training is being undertaken experimentally in a pilot version of Computer Applications in the Humanities, and we are asking for support for to develop materials for use in further versions of that course and for dissemination in other courses.

b. **Access to archival data.** Because applied history tends to focus on relatively recent developments, there are many opportunities to use longitudinal data prepared by social science investigators in a number of disciplines in recent decades. These data include polling data, the National Election Survey returns, and the results of many specialized social research projects, which are available through ICPSR and other repositories. In addition to the problem sets to be developed out of such materials (item A, above) we would like to encourage students in the Introduction to Applied History to tap into these resources when carrying out their own research projects. For students who have already had our computer applications course or some other programming course work beyond the introductory level this should not present serious problems.

4. **Data manipulation, display and presentation.** There are a number of computer resources which are available in our immediate environment and of which we would like to take advantage:

a. **Demographic modelling.** Our computer center already has a package which is capable of very sophisticated display of demographic information. We would like to develop problem sets by which students in the Introduction to Historical Demography could work interactively with, say, data on a hypothetical pre-industrial community with a given age-structure. It would be possible to display instantly the effects of a famine or epidemic of certain dimensions, not only immediately, but over the succeeding several generations. We see this as a way to convey some subtle concepts very powerfully to the students.

b. **Policy option assessment.** For a similar purpose, we would like to adapt for the Introduction to Applied History a computer package designed by a team in CMU’s School of Urban and Public Affairs, which enables one to do a cost-benefit analysis and assess the economic impact of various welfare and tax-reform policy options on selected groups of individuals.
3.6. English and Rhetoric

Background: It is one of the goals of the composition and rhetoric program at CMU that the computer be exploited to meaningfully address concerns in both the craft and art of writing. In the following sections, we briefly review uses of the computer now envisioned in undergraduate composition and rhetoric courses at Carnegie–Mellon.

An Automated Writing Skills Center. Plans are currently underway to set up a fully automated writing skills center. In this center, students with "remedial" writing problems can receive instruction in basic syntax, paragraph structure, organization, and diction. They can submit their essays to programs which will analyze them on various criteria of "readability."

A Computer Supplement to the Freshman Writing Course. One section of the freshman course involves writing mechanics. It is planned that large parts of this section will be taught on the computer and through the automated writing center. Class time will be spent teaching students some highly explicit principles of readable prose. They then will be directed to programs that can give them assessments of how well they have incorporated these principles.

Some of the programs contemplated to assist in writing instruction will be (some already have been) exported from the outside. However, some of these programs will be developed within the rhetoric program. Two programs currently under development are:

A Program Drill in the Analysis of Argumentative Prose. This program, being developed by a graduate student in the Rhetoric program, tests students' ability to read and logically analyze (into premises and conclusions) an argumentative paragraph. The program operationalizes the bottom–up search heuristic for the premise–conclusion breakdown of arguments taught at Carnegie–Mellon by philosophy instructors who use Thomas' book, Natural Language Reasoning.

A Text-Editor With Compositional Heuristics. Much of the work in composition calls for teachers and researchers to look at the writer's processes rather than the finished product. Yet this is very difficult because it is far from obvious how to save or store the writer's early drafts efficiently. A text-editor system named DRAFT is now under development which turns the traditional writing "classroom" into an interactive text-editing environment that can, among other things, allow the teacher to keep a trace of everything the writer does up to the finished product. DRAFT comes equipped with a data–driven instruction file so that the teacher can create special help files and instructional "sequences" for each new lesson.

At present, two upper division courses are being planned that utilize writing and computer
Logic, Epistemology, and Rhetoric. This upper division interdisciplinary course, designed by faculty of philosophy and rhetoric, is an integration and extension of the core courses in writing and philosophy. Its purpose is to give students a more mature understanding of and facility with the conceptual, presentational, and stylistic factors that go into producing a well-reasoned argument essay. The first part of the course, "logic and dialectic," delves into questions of value theory, formal logic, and dialectic, questions that a writer must address when planning an argument in a problem-solving environment. The second part of the course, "stylistics and dialectic," delves into the presentational and stylistic problems that face the writer once he or she has come upon an adequate conceptual solution but needs to solve further problems of adaptation and presentation. The word "dialectic" is used in both sections of the course to enforce the idea that writing should be a process of controlled thinking from beginning to end. Plans are underway to teach the whole course on-line using DRAFT. Plans are also underway to turn the course contents into a comprehensive writing text.

Writing and the Systems Perspective. This course, to be team taught by a member of the rhetoric and computer science faculty, looks at writing the way any scientist looks at a complex system that does not submit to easy mathematical description. Students are introduced to a systems perspective; they are taught how to run computer simulations on systems considerably simpler than human writing; they are introduced to a few simple "parameters" of writing that influence a writer's final product; they are then asked to construct their own simulation to see what sort of text they can produce. Their simulation should give them two types of information. First it should tell them whether the ordering assumptions they built into their model are correct. Second, and more importantly, their simulation should give them a healthy appreciation of how many relevant parameters they have left out, parameters that must ultimately be accounted for before a realistic model of writing can be proposed. The possibilities are so rich that philosophers are bound to embrace the enterprise once the potential of the computer is demonstrated by examples of the kind described.
4. A Case for Normative, Quantitative & Technological Literacy

-- Example: Technology-Induced Risk Assessment & Regulation

Life is rife with risk. This unassailable observation is often meant to calm our nerves, to counsel serenity, to render risk acceptable in this or that case. As if to say, with so much risk abounding, why not just relax and accept it as a natural cost of living?

We are naturally more discriminating.

Especially regarding widely shared, societal risks induced by human technology and susceptible to social regulation.

Which risks are desirable? Which necessary? Which unacceptable? Which, in particular, have we some right to be protected against? And what regulatory measures do our rights enjoin, permit, or proscribe?

The acceptability of risk is a complex matter — in part, as a function of the complexity of the quantitative assessment of risk itself; in part, as a function of irreducible normative factors in the assessment of risk.

Risk assessment—societal risk assessment—in the final analysis involves the weighing and balancing of competing societal interests and basic rights. I argue that current dispute about risk assessment and health and safety regulation has neglected crucial rights and conditions of choice, consent, and voluntary risk assumption.

These normative factors are neither quantifiable nor otherwise fungible. However, technology-induced risk assessment and management requires literacy with the technologies that can both induce and control risk, and with the quantitative disciplines involved in its technical assessment. While I will stress the normative issues that are too often neglected in risk assessment, a liberal education for this technological and risk-rife age must certainly prepare a person to address such a problem in all its problematic dimensions.

4.1. Risk

Decision making 'under risk' is, strictly speaking, decision making where some meaningful (numerical, determinate) probabilities can be assigned to states of nature (or the possible outcomes of alternative decisions). For some decision theorists, 'risk,' as a strict term of art, means simply 'probability.' But we hardly want to say that there is some risk that, having
entered, I will win $1,000,000 in the Pennsylvania lottery.

The missing dimension of concern here is the bad news we associate with risk: the potential injury, loss, or harm. But the quantifiable or probabilistic dimension of risk can be crucial: Risks concern us more when they involve a high probability of harm, less when the probability of harm is low.

Often, however, risks that concern us are possible harms that cannot be assigned determinate, numerical probabilities. Or potential harms whose statistical probabilities mean little to us.

For example, many people who fear flying are not assured by actuarial statistics, and many pay premiums for flight insurance at airports that are 30 times the actuarially fair value.

The fact that there is a .00016 probability that I will be hit by an oncoming car I do not see while pulling out of my driveway, a .003 chance that I will be injured if hit, and .0001 odds that I will die of the resultant injuries 'means' less to me than the brute fact that a friend of mine died as the result of a broadside collision when pulling out of my blind driveway just last week. The proximity of the fatal accident, in time and personal association, makes the potential harm itself the more vivid and salient; the perceived risk looms larger in my mind than do the Department of Transportation statistics.

Suddenly the generalized, societal risks posed by driveways blinded by parked cars and large shade trees seem less acceptable. The risk imposed by legally parked cars that obstruct visibility seems unfair — How to weigh the societal convenience enjoyed by some against the risks imposed on others? Probabilities don't provide the answer, and may not even be material.

Our subjective sense of risk, susceptible as it is to myriad influences, may not heed the objective, actuarial data. But subjective risk perceptions are material to our choices and preferences, and we do seem to value the right to make choices irrespective of their being at odds with the conventional wisdom or the actuarial odds: How we feel about the odds and potential harms is often all we need to know. This means that strict probabilities do not define all the relevant realms of risk.

For commonsense purposes we might define 'risk' as 'a chance of harm,' even though the term 'risk' may properly be applied to the element of chance itself, the potential harm in question, or the occasions or causes associated with the harm in question. Some define 'risk' as exposure to a chance of loss or harm. Since we like to talk about exposure to risk, and
since the term has several proper applications, suffice it to recognize that risk as a practical concern contains an element of chance and an element of potential harm or loss.

The element of chance may be (a) quantifiable (i) as a determinate probability based on current actuarial data or (ii) as an estimate based on some statistical model or projection from historical data. Or the element of chance may be (b) indeterminate and uncertain or (c) subjectively perceived to be high, low, or negligible regardless of actuarial evidence.

4.2. Risk Assessment

'Risk assessment' typically emphasizes the science and art of quantifying the chance and magnitude of the potential harm involved in a given risk. Risk–benefit analysis attempts to calculate the probabilities and magnitude of potential harms against the benefits accruing to exposure to given risks. I take it that the point of risk assessment is, ultimately, to determine whether or not a given risk is acceptable. To this end, quantitative estimations of the probability and magnitude of a given hazard may be material but not sufficient.

Many find the risks of nuclear armament unacceptable. Many (more perhaps) do not. But the issue is neither joined nor resolvable on grounds of probabilities. And we hardly need finer–grained analysis of the magnitude of the hazards.

The risk perception literature teaches us that people's untutored evaluations of risk are often at odds with our theories of rational choice, contrary to actuarial indicators, and biased by all manner of factors in the presentation of facts about the risk in question. This is disturbingly true, for example, in informed consent transactions between patients and physicians: the same facts of risk presented in different ways can yield contrary choices of alternative treatments by the patient. People's choices must often be respected nonetheless, and this is not a decision–theoretic paradox but an ethical and political one.

In many cases, the manner in which a risk is posed or mediated can be decisive to its acceptability: where we have nothing or little to say about whether or how we are exposed to a risk, no quantifiable calculation of risk and benefits may make it acceptable.

Our assessment of the acceptability of any risk will be a complex function of our respective assessments of (1) the element of chance, (2) the nature and magnitude of the potential harm in question, (3) the countervailing benefits of exposure to the risk in question, (4) the distribution of risks and potential benefits, and (5) the manner in which we are exposed to the risk.
The latter two factors involve issues of equity and rights that are irreducibly ethical. The second factor, which effectively involves the selection of certain hazards as high priority concerns, also involves the weighing and balancing of societal priorities and basic rights.

The risk analysis literature tends to be preoccupied with the quantifiable dimensions of risk assessment, the scientifically more tractable dimensions: risk measurement, economic and utility-theoretic frameworks for risk–benefit calculations, and the experimental study of factors influencing risk perception. This literature is rich and undeniably important for anyone interested in risk assessment, abatement, or management.

But decisions about the acceptability of risks and how exposure to risks should be regulated or mediated must often be made in the absence of conclusive scientific findings. And our scientifically untutored perceptions of risk, however at odds with actuarial data or decision-theoretic norms, often demand respect: we presumably have rights against exposure to certain risks to which we are averse, no matter what the odds for potential harm or benefit; and we presumably have rights to take certain risks, no matter what the chances of harm to ourselves.

The bottom line in the assessment of the acceptability of societal risks and the consequent deliberation of regulatory policy will often be determined not by risk–benefit calculations but by the weighing and balancing of the putative rights and non-fungible social values in question.

4.3. Regulation: Respecting Rights

4.3.1. The Priority of Rights to Choose and to Consent

Any case for or against the acceptability of societal risks and mechanisms for regulating them will hang in part on our understanding of our putative rights and associated social values.

I take it that the problem of deliberating trade-offs and setting priorities among competing social values and rights is paramount in defining the bounds of acceptable societal risk and the scope of legitimate government regulation.

The legitimacy of government regulation of our risky lives and industry is based on a presumption of public consent: the function of government regulation is to protect the public's interests, in virtue of which it merits public consent to its strictures. In protecting the public and individuals from unwanted harm or risk to their health, welfare, and property, regulatory constraints are presumed to respect the liberty and autonomy of individuals, their freedom to choose whatever pursuits, so long as those pursuits do not interfere with the like
Thus, so-called 'free' choice and consent are respected on two levels: in the right to choose or consent to transactions in our individual lives; and in the right to have a say in the regulatory measures that presumably safeguard the conditions of free choice and consent in our individual lives.

Our right to be secured against harm is only apparently the *raison d'etre* of government regulation; security is only apparently the bottom-line incentive for even a Hobbesian social contractor. The priority right in question is the right to be secured against unwanted harm, harm which we do not choose to suffer or risk (or which we would not choose to suffer or risk if we could freely so choose).

Rights to security against harm or risk are derivative of the priority we place on respect for individual autonomy: that we give priority not to freedom from harm but rather freedom to choose or consent is evident from the importance we place on safeguarding our right to make harmful mistakes in deciding for ourselves what risks to assume in matters that concern only our own personal welfare.

4.3.2. Risks to Rights and Rights to Risk

The risks to health and safety that have come in for priority attention in recent years are not merely risks to health and safety *per se*, but at bottom risks to our rights of choice and consent. If health and safety alone were paramount, we need not be concerned about the mobility and transaction costs that constrain a worker's choice of workplace or occupation.

If health and safety alone were paramount, we would not simply outlaw ads for cigarettes that bias choice but would also outlaw their sale and purchase. Regulation poses risks to the very rights it seeks to secure so far as our rights to risk are disregarded. At bottom, it is respect for our rights of choice and consent that both enjoin and limit regulatory constraints.

This admittedly arguable hypothesis about the structure of our putative rights at least accommodates the apparently conflicting classical liberal principles of legitimate social control, to wit: coercive constraint is justified only to prevent harm to innocent parties; and coercive constraint of an individual for his own good is never justified except to safeguard his freedom to choose what he thinks best for himself: You may lay hands on a person to inform him that the bridge he is about to cross is in danger of collapsing from his weight, to assure that his decision to cross is informed and, so far, 'free'; but once he is apprised of the risk, you...
may not detain him solely for his own good. Mill’s famous case is deceptively prosaic.

John Stuart Mill’s proscription against paternalistic constraints on individual liberty excepted cases where such constraints would on balance secure or enhance the individual’s ability to make a free and informed choice: in matters that concern only the agent’s welfare we may interfere only if the agent’s choice is not free and informed. Mill proscribed selling oneself into perpetual involuntary servitude on the grounds that one could not invoke the principle of liberty in order to justify its perpetual abrogation.

The only justification for paternalistic constraint of individual autonomy is, by this account, respect for autonomy itself. The same priority at bottom motivates non-paternalistic constraints: to prevent unwanted harm to individuals, to prevent harm or risk that an individual would not choose to suffer if he were in a position to freely so choose.

The right at risk with and without state regulatory constraints is the same, namely: the right to freely choose or consent to the harms one will risk.

4.4. Neglect of Consent-Rights in Risk Assessment & Regulation

This provisional analysis of the rights and societal priorities that define the scope of acceptable societal risk and its regulation need not be accepted in order to see the pivotal importance of rights of choice and consent in the assessment of risk and regulatory policy. The risk analysis literature takes it as axiomatic that in deliberating which risks to regulate and which to allow we must at least distinguish voluntary from involuntary risk.

The problem is defining the conditions of 'free' choice, 'informed' consent, 'voluntary' risk assumption and showing how we can take better account of these factors in the deliberation of health and safety regulation. This problem is widely acknowledged but only cursorily treated in the risk-analytic literature, in the literature on regulatory policy and reform, in regulatory legislation, litigation and judicial review, and in the popular press.

The regulatory initiatives that gained such momentum in the previous decade (OSHA, EPA, the CPSC, etc.) are now under duress from libertarians and other opponents of 'big' government. The issue here is not whether the public should be protected from unwanted harm or risk to its interests in health and environmental quality. It is rather often cast as a dispute over the appropriate mechanisms for the regulation or mediation of these risks.

Two competing regulatory mechanisms are command-and-control regulation, which seeks to
limit exposure to certain hazards by direct prohibitions on production, distribution, or consumption; and information-based regulation, like 'truth-in-labeling,' which seeks to secure the public against unwanted harm or risk through the provision of adequate information for informed choice and avoidance.

The issues between these alternatives are frequently joined on grounds of economic efficiency and economic freedom. The adequacy of information-based measures for ensuring the public health and safety, as against direct command-and-control, must certainly be assessed within some explicit framework of conditions governing 'free' choice, 'informed' consent, 'voluntary' risk assumption, and the associated rights.

This is all to say that one crucial factor in the assessment of risk and measures appropriate for its regulation is largely left out of account in the public, legislative, and policy-analytic arenas, namely (5) (Section 2 above): the manner in which we are exposed to risk, the means available to the person or population at risk to assess, mediate, or avoid the risk in question. (In the academic arena, philosophers are just beginning to address the implications of consent-rights theory for the assessment and management of societal risks. Work in this area has been begun but so far is unpublished, to my knowledge, at the Center for Philosophy and Public Policy at the University of Maryland. Nicholas Rescher, a philosopher at the University of Pittsburgh, has a book in the works on risk and risk management; I do not know what role if any consent-rights theory plays in his project.)

The situation in the area of societal risk assessment and health and safety regulation is in stark contrast to other areas of risk assessment and management where free choice and consent are paramount, namely: biomedical policy and law regarding the manner in which patients or subjects are exposed to the risks of treatment and medical research. The critical philosophic literature in these areas is similarly rich.

I will hazard that in spite of the disanalogies between these two broad areas of risk confrontation and mediation, there are many parallel and analogous issues respecting the rights and conditions of free choice, informed consent, and voluntary risk assumption. The statutory provisions and judicial review of the requirements of informed consent in, for example, hospital law are often philosophically wanting. But consent-rights issues are faced forthrightly and explicitly, and there exists a large body of jurisprudential wisdom for their negotiation and adjudication.

Cognate conceptual frameworks have been long in development in other areas of jurisprudence and law, namely: tort and product-liability. These traditions antedate the
development of issues of economic efficiency that preoccupy contemporary jurisprudence in general and the risk-assessment and regulatory disputes in particular. Consequently, common law rights and notions of consent figure more prominently in their continuing evolution.

I suggest that contemporary disputes about risk assessment and health and safety regulation could benefit from critical philosophic analysis of our putative rights and notions of free choice, informed consent, and voluntary risk assumption; and that this analysis would do well to examine the treatment of these rights and concepts in analogous areas of ethics and jurisprudence.