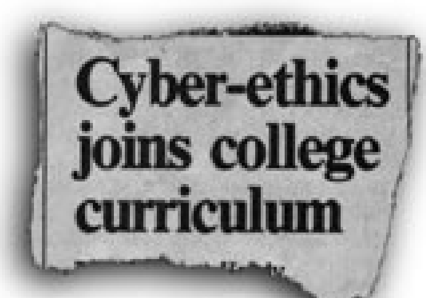
How to prepare tomorrow's professionals for questions that can't always be answered with faster, better, or more technology.

Computing Consequences: A Framework for Teaching Ethical Computing



A fundamental change in the computer science curriculum in the last decade is acknowledgement that the context in which technology is used must be reflected in the technology's design—because of the ethical implications of its use and because understanding the consequences of such use helps improve the design [2, 19]. This insight was included in Computing Curricula 1991 [22], a report from the ACM/IEEE-CS Joint Curriculum Task Force, and has been a part of Computer Science Accreditation Board curriculum standards since 1987 [1, 4]. Thus, the social, ethical, and professional context of the technology was added to the core undergraduate curriculum as part of the natural evolution of the maturing computer science discipline.

Interest in the consequences of computing is especially important because most computer science majors expect to use their education in industry. From the student perspective, a curriculum that emphasizes computers in the world in which they will work is quite practical. Computer scientists in industry regularly face questions requiring professional judgment that cannot be answered in precise mathematical terms. Such questions include:

- Who is accountable when bugs in medical software result in patient deaths?
- Is being an impostor on a bulletin board system, creating vio-

Chuck Huff and C. Dianne Martin

lations of trust, mitigated by the fact that some positive result is also achieved?
- When a multimillion-dollar software project is behind schedule, should technical staffers who doubt it can be rescheduled and completed as promised inform the client organization?
- Should there be limits to how managers and owners of private firms examine the movements of their employees?
- Should employees or managers anticipate the possibility of ailments from intensive computer use, such as repetitive strain injuries? Who is responsible for taking preventive measures?
- Are computer scientists morally responsible for anticipating and publicizing the problems that could result from the systems they designed?

Rigorous training in mathematical theory and computational technique does not prepare students for these and other questions, but students can be taught to expect them and to think clearly about them. Students need a careful and critical examination at the undergraduate level of the ethical and social issues involved in computer design and use.

Project ImpactCS

The importance of these issues was underscored by Computing Curricula 1991, which identified social, ethical, and professional issues as subject areas in its requirements for an undergraduate computer science curriculum. However, the report offered little guidance for those who would teach these subject areas. Earlier reports, like Curriculum 78 and the Computer Sciences Accreditation Board Guidelines, provide high-level guidelines for teaching about the consequences of technology, rather than specific recommendations for content or pedagogy [1].

Project ImpactCS, begun in 1994, seeks to define the core content and pedagogical objectives for integrating social impact and ethics into the computer science curriculum. For the next two years, the project will address three major problems that hamper the implementation of across-the-board curricular change:

- Lack of a specific definition of what the core content and learning objectives should include;
- Lack of a strategy for adapting and adopting existing materials that address the core topics into the existing computer science curriculum; and
- Lack of awareness and expertise on the part of most computer science faculty regarding the need and methodology for presenting such material in their courses.

The first stage of the project in 1994 involved convening a Steering Committee of experts in ethics, social impact, and curriculum design to provide a conceptual foundation for courses and course modules. This article discusses the results of the Committee's work. During the second stage now underway, Project ImpactCS is collecting and disseminating a variety of practical materials to help instructors teach the principles and skills outlined here. The final stage, scheduled for 1996, will consist of a pilot faculty enhancement seminar to present the principles, skills, and practical pedagogical tools to computer science faculty members.

Using the Computing Curricula 1991 Report [22] as a model, Project ImpactCS now provides the conceptual framework and rationale for defining a new content area in the computer science curriculum with the same intellectual rigor used to define the other content areas. This article represents our effort so far to address the first problem—development of core content and pedagogical objectives for integrating social impact and ethics into the computer science curriculum.

The Steering Committee's work began at a two-day meeting in August, 1994, by convening 25 experts, all well known in computer ethics and social impact, including philosophers, social scientists, ethicists, and computer science professors with expertise in computer science curriculum accreditation issues. This meeting produced a conceptual framework, the pedagogical objectives, and a database of topics and teaching methodologies that became the basis for the Project ImpactCS report, which was circulated to Committee members at each stage of its development.

Conceptual Framework

The study of ethical and social issues in computing is interdisciplinary in nature. Ethicists, historians, social analysts, sociologists, anthropologists, and psychologists have all contributed to research in this area. Instead of suggesting that students learn each discipline separately, we suggest that from the perspective of computer science, every ethical concern is located at a particular level of social analysis. Only analysis that accounts for at least three dimensions—technical, social, and ethical—can represent the issues as they affect computer science in practice. Considering each dimension separately provides some insight, but only their interaction reveals the complexity of the issues. Analysis of any ethical issue should also specify and examine the related social analysis and technical content.

Figure 1 shows in detail the Steering Committee's effort to define the two dimensions—social analysis and the ethical issues associated with technology. A third dimension is indicated, but not specified for including the various technologies requiring analysis from some portion of the first two dimensions.

Technologies

		Topics of Ethical Analysis								
		Responsibility		Ethical Issues						
		Individual	Professional	Quality 0f Life	Use of Power	Risks and Reliability	Property Rights	Privacy	Equity and Access	Honesty and Deception
Levels of Social Analysis	Individuals									
	Communities and Groups									
	Organizations									
	Cultures									
	Institutional Sectors									
	Nations									
	Global									

Figure 1. Intersection of ethical and social analysis

Because technology changes so quickly, specifying the technologies would limit the use of the conceptual scheme and unnecessarily date our effort to specify this dimension.

Each ethical issue represented by a column in Figure 1 is covered at length in primary and secondary scholarly literature, as well as in popular and academic venues. By itself, philosophical work on the concept of property could fill several bookshelves. Each level of social analysis (the rows in Figure 1) also has associated literature, including thousands of references. Combining these two dimensions results in so much research and analysis it is difficult to know where to start.

Fortunately, we have a rule—in the form of a question—to help determine our starting point: What topics, principles, and skills from this array are relevant to undergraduate computer science students? The result is that the issues concerning computer professionals—often dealt with in codes of ethics—are fundamental parts of the topics in Figure 1; the approach when addressing these issues is that of the computing professional, not that of the philosopher or the social scientist. The issues are also integral because the issues of individual and professional responsibility should be addressed when dealing with every topic, although for pedagogical purposes, we include a column with that title.

Interacting Dimensions

Each of the three analytical approaches—ethics, social science, technology—represented by the dimensions in Figure 1 is important in its own right,

Project ImpactCS Steering Committee

Ron Anderson, University of Minnesota; John Artz, The George Washington University; David Bellin, North Carolina A & T State University; Tim Bergin, American University; Louis Berzai, University of Notre Dame; Terrell Ward Bynum, Southern Connecticut State University; Peter Caws, The George Washington University; Frank W. Connolly, American University; Batya Friedman, Colby College; Donald Gotterbarn, East Tennessee State University; Charles Huff, St. Olaf College; Deborah Johnson, Rensselaer Polytechnic Institute; Rob Kling, University of California, Irvine; Blaise Liffick, Millersville University; Joyce Currie Little, Towson State University; Walter Maner, Bowling Green State University; C. Dianne Martin, chair, The George Washington University; Keith Miller, University of Illinois, Springfield; Michael Mulder, University of Southwestern Louisiana; Eric Roberts, Stanford University; Richard S. Rosenberg, University of British Columbia; Ronni Rosenberg, Consultant; Patrick Sullivan, Computer Ethics Institute; Albert (Joe) J. Turner, Clemson University; Harry Yeide, The George Washington University.

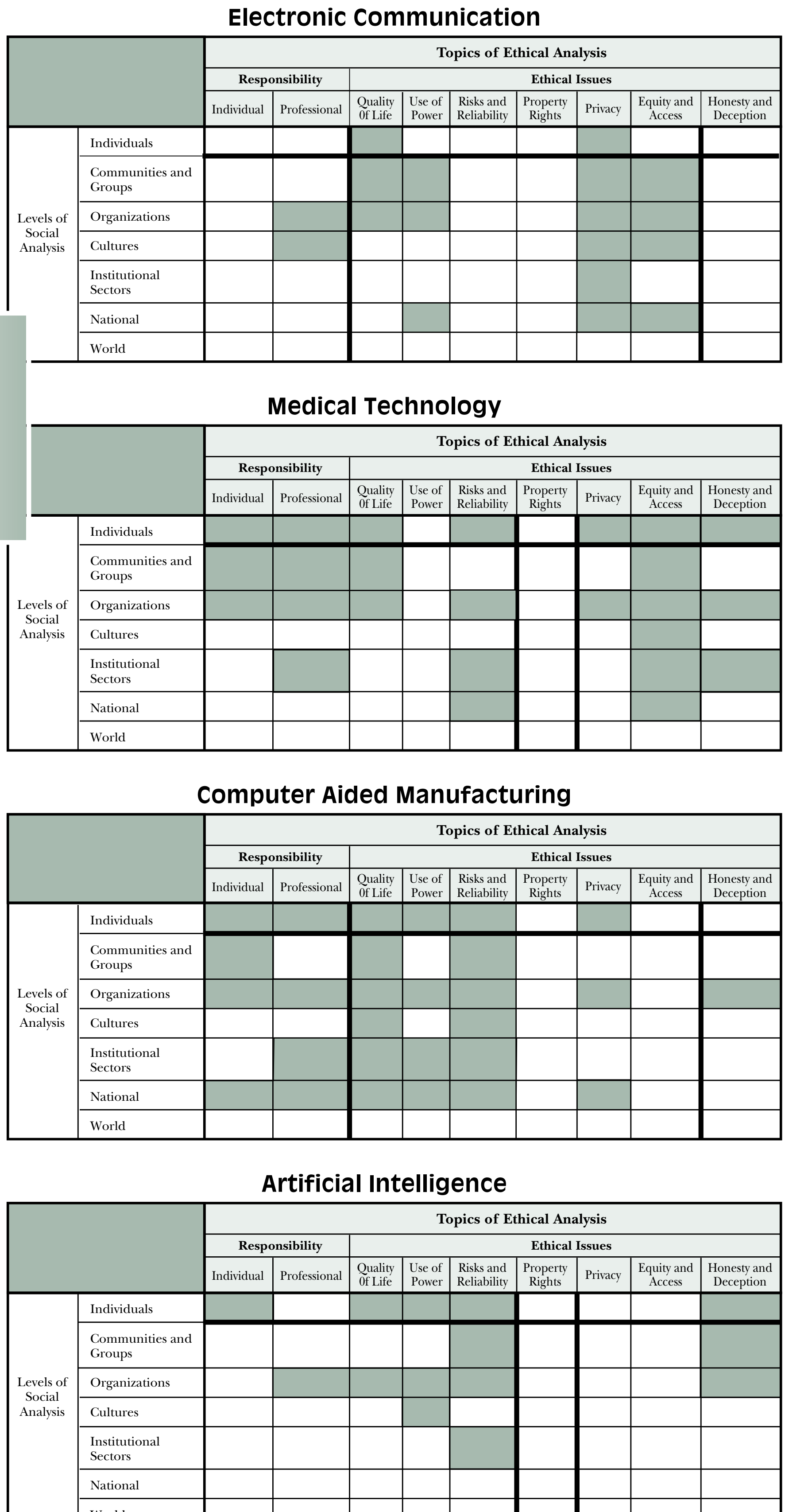


Figure 2. Areas of ethical concern for sample technologies

with its own practitioners, literature, and approach. However, because any ethical or social issue in computing is multidimensional, it requires careful presentation. Some knowledge of these dimensions by the instructor is essential to the success of a course on social and ethical issues in computing. Moreover, all three approaches are needed to understand a particular issue. General principles about social analysis may be useful, but they should also be connected to their implications for ethical computing.

This interaction is represented in Figure 2 in which the shaded areas are hypothetical areas of social and ethical concern for four technologies. Note each technology is associated with different areas of concern and that each area involves social analysis and an ethical issue. Any particular issue, such as privacy in corporate records or risks in medical technology, covers many levels of social analysis and several different ethical issues; it is also spread across various implementations of the technology. Analyzing any issue must address all these dimensions. Even a short analysis, like one in a course module, needs to at least show students the complexity of what may seem to be a simple problem.

This section examines why each level of analysis or ethical issue identified in Figure 2 is important to analyzing computer technology from the viewpoint of the computer professional. We do not claim that these ethical issues and social analyses are a comprehensive taxonomy of the field; that is too much to expect from a new approach, and only extensive use will determine if the categories or conceptual scheme need revision. We do, however, claim that this is a reasonably comprehensive and useful categorization of the issues.

A common approach in social analysis is to first determine the level of analysis required for a particular issue and then apply the tools, literature, and methods appropriate to that level. There is no "privileged" level because many issues must be analyzed at several levels to understand them. But it suggests that determining the appropriate levels of analysis helps teach social and ethical issues in computing. The following sections include descriptions of each level of analysis, examples of a few issues worth analyzing at each level, and suggestions about how a particular level interacts with the ethical issues represented by the columns in Figure 1.

Individuals. Even relatively homogeneous groups and organizations do not employ universal approaches to technology. Such differences may be based on their members' physical and psychological differences. Awareness of individual diversity is helpful to students of computer science [18]. And system designers should know who will use their systems. If employees will use it, for example, designers should know whether their design will facilitate employee use. Then there is the question of how responsible—legally and ethically—are designers for adapting their systems for people with physical handicaps? Computer professionals need to know how their decisions affect users and how users influence the use of the technology.

Communities and Groups. Technology is rarely designed for or used by one person alone. For example, communication technologies are usually designed by teams of computer professionals to connect many people. Groups of people are motivated by common interests, although disagreements about purpose characterize their internal discourse. The concerns of these groups influence how systems are designed, as well as how they are used.

Moreover, computer professionals usually do their work in teams. Because no individual is assured of always being the most powerful person on a team, team members must make decisions about design and implementation issues in the context of the group's interactions and power hierarchy [3, 10, 13]. When working in groups and designing technology to be used by groups, computer professionals need to deal with social interactions.

Organizations. Any organization is likely to include differing points of view on the use, regulation, promise, and design of technology. These differences depend on several factors:

- Organizational structure and culture;
- Workplace procedure;
- Members' power and areas of interest; and
- Members' position in the corporate hierarchy

However, organizational imperatives that require work groups to value production above all else often lead to poor quality computer products and services or even unsafe systems.

Cultures. We include in the category of cultural divisions the groupings that cut across local group, organizational, and even national boundaries. For our purposes, gender, race, economic class, and reference groups, such as hackers and computer professionals, are examples of cultural groups. Such groups need to be considered by computer professionals when designing and implementing systems. Computer professionals also must remember that different regional cultures, like European and Asian, view ethical issues from different perspectives, and in the increasingly global market, designers of systems likely to be used in multiple cultures must understand the different approaches taken by each culture [21]. Recognizing authentic cultural differences—rather than relying on stereotypes—helps designers produce and implement systems more widely accepted, and perhaps even safer when used in cultures different from that of the designer.

Institutions. The various institutions in each culture or country are characterized by different interests, preferences, approaches, and assumptions when addressing ethical issues in computing. Government agencies, business societies, scientific organizations, charitable institutions, professional societies, and labor organizations differ in their interests and concerns about particular technologies. In addition, particular technologies are likely to be used differently by different institutions, whose interests in their regulation also differ. Computing professionals deal with many such institutions in their careers and should know they do not all share interest in or approaches to technology.

Global vs. Local. Ethical issues in computing are no longer isolated from the national and international scene. Given the global diffusion of technology and the links among various technologies in communication networks, even seemingly local decisions about reliability, standards, access, and privacy can have global implications. For example, many proponents of the Internet assume that democratic values will spread along with the technology. But some countries may be interested in the technology and connectivity promised by the Internet, yet are leery of the assumptions of power sharing and democratic participation that Western advocates view as inseparable from the technology [20].

Topics of Ethical Analysis

The following sections explore the topics of ethical analysis outlined in Figure 1.

Individual and Professional Responsibility. We are convinced that individual and professional responsibility is a prerequisite for discussing the other issues in Figure 1. However, for pedagogical reasons, it is useful to include them as two columns set apart for special consideration. It is also crucial for students to examine their own ideas of individual and professional responsibility, especially in the context of a course that highlights the social and ethical concerns associated with their future profession.

Individual responsibilities include the moral imperatives in the ACM Code of Ethics, such as:

- Avoid harm to others;
- Be honest;
- Be fair; and
- Take action to not discriminate.

Computing professionals should accept their professional responsibilities because of their special knowledge and skill, their association with others who share that knowledge and skill, and the trust society places in them. To the extent that computing is a profession, its practitioners should shape the profession in ways at least socially benign, and ideally socially beneficial. The professional responsibilities outlined in the ACM Code of Ethics are a reasonable list, corresponding to many of the issues in Figure 1. Knowledge and practice of these responsibilities is fundamental to ethical thought and behavior by computer professionals.

Quality of Life. Many claims for increased quality of life are one-dimensional, but computer professionals must ask whether "faster, better, more" always results in increased quality of life for users. We should consider the possibility that technology can have undesirable effects, as well as good results. Such reasoning can be painful, but is necessary for computer professionals who want to be honest about the effects of the technologies they design.

Use of Power. Knowledge gives computer professionals power. To the extent that new technology is not constrained by physical or mathematical principles, each design decision for the technology is an exercise of power. Computer professionals in turn have power exercised over them as members of organizations and work groups. They deal with the ethical dilemmas that face anyone acting as the agent of others. They are responsible for being good agents, and for considering the users affected by their actions. However, balancing these responsibilities can produce some excruciating ethical conflicts.

Risks and Reliability. Because error-free design is impossible to achieve and to measure, computer professionals must know the risks associated with technology. For example, designers of critical safety systems must make choices and tradeoffs in design and implementation. Anticipating the ethical dimensions of these choices yields more thoughtful and informed design decisions.

Property Rights. The ACM Code of Ethics pledges ACM members to respect copyright and other property laws, but what does disregarding the law mean if technology makes information infinitely reproducible without degrading the original? The law on patents, trade secrecy, and copyright is evolving to account for new technology, and computer professionals ignorant of the legal and ethical issues are likely to stumble across these changes when designing and implementing systems.

Privacy. Computing professionals regularly design systems that collect, store, and transmit data about people. Most legal and ethical systems recognize the right to privacy, the right of the individual to determine what data is collected about them, by whom, and for what purposes. Privacy expectations, which differ among individuals, cultures, and nations, need to be incorporated in systems that handle personal data. Moreover, because computing professionals know the potential uses and abuses of the technology, they should know how to participate in the public dialogue about privacy.

Equity and Access. What responsibilities do computer professionals assume when designing technology that may dramatically alter societal access and power relationships? Since computer professionals design the systems and influence decisions about implementation, their opinions on these matters should not be based solely on empirical evidence about inequities, but also grounded in careful ethical reasoning about information equity and access.

Honesty and Deception. The respect and influence that computer professionals want in the public arena depends on the public's perception of the profession as honest. And honest, clear, and comprehensive appraisals of the benefits and risks of technology help maintain that respect. Some reflection on how competing interests balance each other is surely helpful since these issues are likely to confront students early in their careers.

Principles and Skills Supporting Ethical and Social Analysis

The goal of a curriculum is to prepare students for new issues as they arise in practice. Given the changing nature of computing technologies, issues different from those addressed in school are likely to arise. Emphasizing the principles and skills that foster understanding of many issues enable students to be more flexible in their approach while helping instructors avoid sticking to social and ethical topics du jour.

The principles and skills from the technology dimension were covered in Computing Curricula 1991. Here, we analyze the principles and skills of ethical and social analysis to which undergraduate students of computer science should be exposed. Figure 3 lists the main principles and skills. Note they are universally useful, not tied to the technical attributes of particular technologies. They are, however, important for computer scientists when designing and implementing technologies. Note, too, the particular topics and levels of social analysis in Figure 1 should be viewed as a means for teaching these principles and skills.

Ethical Principles

Ethical claims can be discussed rationally. Many people are passionate about the ethical issues confronting computer professionals. However, even the strongest emotion can—with careful analysis—be articulated in terms of its structure and supporting reasons. These reasons can also be evaluated in terms of criteria, such as consistency, logical coherence, agreement with accepted standards, such as codes of ethics, and applicability to a variety of cases. No criterion is foolproof or represents an infallible methods of evaluation, but all are rational methods of evaluation.

Ethical claims must be defended with reasons. Because students need to defend their opinions and decisions when they go to work, they should be able to define and evaluate the reasons behind their opinion and decisions. Students are told to evaluate the reasons they give, but learn to do so only through practice, using such criteria as consistency, logical coherence, agreement with accepted standards, such as codes of ethics, and applicability to a variety of cases.

Figure 3. Ethical and social principles and skills for computer science undergraduates

Ethical Principles
- *Ethical claims can be discussed rationally.*
- *Ethical claims must be defended with reasons.*
- *Ethical choices cannot be avoided.*
- *Some easy ethical approaches are questionable.*

Ethical Skills
- *Arguing from example, analogy, and counter-example.*
- *Identifying ethical principles and stake holders in concrete situations.*
- *Identifying and evaluating alternative cources of action.*
- *Applying ethical codes to concrete situations.*

Social Principles
- *Social context influences the design and use of technology.*
- *Power relations are central in all social interaction.*
- *Technology embodies value decisions made by designers.*
- *Empirical data is crucial to the design process.*

Social Skills
- *Identifying and interpreting the social context of a particular implementation.*
- *Identifying assumptions and values embedded in a particular design.*
- *Evaluating, by use of empirical data, a particular implementation of a technology.*

Ethical choices cannot be avoided. Many students think ethical choices are irrelevant to computer science or engineering disciplines and that their job is simply to do their employers' will. However, computer professionals enter the realm of ethical choice in design whenever they make decisions affecting people that are not completely constrained by mathematics or physics. Ethical reflection begins with the assumption that all designs and all implementations involve value choices.

Some easy ethical approaches are questionable. Students need to learn of the common grounds for ethical claims and of the weaknesses of the grounds often used to defend ethical choices. Though most students do not recognize the jargon, they are likely to recognize the differences between ethical reasoning based on the outcomes of action (consequentialism) and ethical reasoning based on duty or rights alone (deontological reasoning). In addition, several questionable and naive approaches to ethical reasoning can lead the novice ethical thinker astray.

Ethical Skills

Arguing from example, analogy, and counter-example. Much moral argument in the common tongue (and in philosophical discourse) involves the use of examples, counter-examples, and analogies. These methods help clarify issues and point out the incoherencies and difficulties in ethical positions.

Identifying ethical principles and stake holders. When considering a particular implementation or reasoning about one's position on an ethical issue, a common mistake is to accept simple definitions of the affected parties. Practice identifying ethical principles and stake holders prepares students to be practicing professionals with more foresight and sensitivity to the issues.

Identifying and evaluating alternative courses of action. More ethical mistakes result from failure of imagination than from failure of moral principle. If you cannot think of alternative courses of action, you have few choices. A practical aspect of ethical reasoning involves determining whether all available options are exhausted. Practice evaluating the alternatives makes it easier to evaluate the options in actual decisions.

Applying ethical codes. Ethics codes represent the consensus of the field with regard to a professional's responsibilities. Students aspiring to join the profession should be familiar with these codes and their application to situations likely to occur in professional life. The methods of ethical reflection we expect students to learn include comparing their intuition and reasoning to concrete cases and to established values in the field.

Principles from Social Analysis

Social context influences design and use of technology. Technology does not simply affect society in a one-way causal chain; the web of causality is much more complex. For example, society influences the shape and development of a technology just as the social and organizational setting in which the technology is used influences the way it is used. In addition, the social context also determines the use of technology once implemented. Deciding not to address the social and ethical values assumed in a particular specification is an ethical decision to allow these values to go unquestioned.

Power relations are central in all social interaction. Social relations are shot through with implicit and explicit considerations of power. Designers of technology should know the power of various parties in an organization when designing software for the organization.

Technology embodies value decisions by designers. A common claim is that technology is neutral with regard to values. Design often involves ethical decisions based on social context and social values, and the technology transmits or embodies the value decisions (and assumptions) made during the design process.

Populations are always diverse. A design principle for human-computer interaction is: design for your user, but remember that you are not your user. This principle is a warning to avoid assuming that others share your preferences and proclivities. The situations in which a technology will be used, the people who will use the technology, and how it will be used are all more varied and diverse than one might first expect. Better to design with this variability in mind than to be surprised by it later.

Empirical data are crucial to the design process. The previous principles suggest that the "real world" may not be what our specification sheets tell us it is. Therefore, a good designer makes every reasonable attempt to know the situation in which software or hardware may actually be used, rather than rely on guesses, speculation, or optimism. Mathematical proofs or tests based on a specification alone ignore the effects of the context in which the technology is used.

Skills from Social Analysis

Identifying and interpreting the social context of an implementation. Computer professionals who design technology need to think carefully about how that technology will be used. Quality design reflects a technology's actual use.

Identifying assumptions and values in a particular design. The claim that a particular implementation is value-neutral is based more on a failure of imagination than on personal bias. Certain technologies may be more constrained by physics and mathematics than others, and thus less subject to value-based choices. Practice identifying embedded values helps students identify similar issues in their future technology designs.

Evaluating, by use of empirical data, a particular implementation. Computer professionals should be able to use empirical data to evaluate the likely use of a technology—as opposed to its planned use—as well as the performance of the technology after its implementation. The designer needs enough data to determine if—within the limits of schedule and budget—the design performs as claimed and if it involves other significant risks. Students need help making professional judgment calls about the limits of evaluation.

Teaching Topics, Principles, and Skills

The principles and skills covered here include enough content for several courses, if the requirement is that all of these things be done in detail and separately. However, in an introduction-to-programming class, students learn at least one programming language, as well as elementary principles of program design and some database structures, while being introduced to many of the recurring principles in Computing Curricula 1991. This is not done by teaching each separately and in detail, but by having students design, implement, and test programs that incorporate these principles and skills.

In the same way, students can cover the topic of privacy by investigating electronic monitoring of workers. Our framework allows such investigations to be grounded in utilitarian and deontological ethical arguments about privacy, while recognizing the importance of the various contexts in even the most monolithic organizations. Students can also analyze a case history of whistle blowing to help understand the nature of individual responsibility. Whistle blowing can be considered in light of what we know about power in organizations, helping students identify how abstract ethical principles from ethics codes work in real situations.

If these issues can be covered more than once, or in more than one place in the curriculum, they will be better understood by students. The power of the conceptual framework we provide is remarkably flexible and can be used in a variety of computer science undergraduate programs.

In the Lab

Computer science is a laboratory-oriented discipline. Most courses incorporate lab work, such as open labs with programming assignments done outside of class and closed labs with assignments done in class. We encourage instructors to incorporate lab work in their courses in two ways:

- Through incorporation of ethical and social issues in the lab work associated with such standard computer science subjects as database design, human-computer interaction, operating systems, and algorithms [7, 9, 16]. Ethical content can range from the simplest real-world dilemma in a programming example [9] to requiring that senior system projects include analysis of the ethical and social impact of their use [11].
- Through courses concentrating on ethical and social issues in computing. Students may be required to interview working professionals about ethical practices or suggesting ways to redesign a product or implementation. Larger projects, such as data analysis for a social impact statement [13, 19], can be linked to the ethical principles and skills.

In both approaches, value is gained not from going through the motions of lab work, but from connecting the abstract principles and skills with real-world examples. Ethical and social issues in computing are viewed not as preaching, but as the thoughtful application of practical skills.

Minimal Implementation

What is a minimally sufficient implementation of the Project ImpactCS framework? A sufficient implementation of this framework covers all the social and ethical principles and skills, at least at the introductory level. Leaving out any significant number of them would drastically reduce the coherence of the curriculum. Moreover, understanding individual and professional responsibility is fundamental to ethical analysis.

A sufficient implementation should also include several ethical issues and several levels of social analysis because understanding any of them inevitably leads to consideration of the others. We cannot conceive of a course dealing with one ethical issue without mention of or recourse to other ethical issues or to specific levels of social analysis [6, 12, 14, 15, 17].

Another issue is how to locate the material in the curriculum. The Steering Committee is unanimous in its commitment that these issues be taught throughout the computer science curriculum, as well as in specific courses [9, 16]. Integration into the curriculum gives students repeated contact, assuring it is understood in the context of its applications to other areas. However, without the specialized course, students would not give enough scrutiny to social and ethical issues. A full course in ethical and social issues in computing assures that MIS departments hire and maintain the expertise of faculty who work in this area. These faculty members then serve as resources to help integrate the issues throughout the curriculum.

Conclusions

Project ImpactCS is a valuable conceptual framework for presenting ethical and social issues in computing to students of computer science. It integrates the literature on how computing affects society with the literature on ethics, helping each approach illuminate the other while providing balance and perspective. It also provides an organized menu of topics for instructors to select and suggests how those topics are related to one another.

The project offers a set of clear, consensual, and learnable principles and skills that are practical in their application, providing a foundation for further thinking and practice in the undergraduate, graduate, and business worlds. Its approach to ethical and social issues in computing can invigorate the teaching of these topics at the undergraduate level. We are committed to integrating topics, as well as to a specialized course, to consideration of several ethical issues and levels of social analysis, and most importantly, to inclusion of the principles and skills. The Steering Committee views the project's approach to integrating ethical and social impact issues into computer science as a positive and profound contribution to the teaching and practice of computer science in the 21st century.

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About the Authors:

CHUCK HUFF is an associate professor in the Psychology Department at St. Olaf College. His current research interests include social aspects of human-computer interaction, ethical and social implications of computing, and the psychology of moral reasoning. **Author's Present Address:** Psychology Department, St. Olaf College, 1520 St. Olaf Avenue, Northfield, Minn. 55057-1098; email: huff@stolaf.edu

C. DIANNE MARTIN is an associate professor in the Electrical Engineering and Computer Science Department at The George Washington University. Her current research interests include education and multimedia systems, ethical and social implications of computing, and development of undergraduate curriculum. **Author's Present Address:** EECS Department, Academic Center, Sixth floor, The George Washington University, Washington, D.C 20052; email: diannem@seas.gwu.edu