Computing and Information Ethics Education Research

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Abstract

This chapter explains and integrates new approaches to teaching computing and information ethics (CIE) and researching CIE education. We first familiarize the reader with CIE by explaining three domains where information ethics may be applied: Information Ownership; Information Privacy; and Information Quality. We then outline past and current approaches to CIE education and indicate where research is necessary. Research suggestions for CIE education focus upon developing a deep understanding of the relationships between students, teachers, pedagogical materials, learning processes, teaching techniques, outcomes, and assessment methods. CIE education exists to enhance individual and group ethical problem solving processes; however these processes are not yet fully understood, making research necessary. We then discuss CIE education research to date and suggest new directions. These directions include applying insights from the field of learning science and developing dynamic and interactive computing and information tools. Since these tools are dynamic and interactive, they will better support collaboration, iteration, reflection, and revision that can help students learn CIE.

Introduction

The primary purpose of this chapter is to indicate the need for research regarding the education of computing and information professionals about ethics. We start by first abstractly describing computing and information ethics (CIE), but then we provide three concrete examples of contested CIE issues. We then move to discuss the progress to date in developing and implementing CIE pedagogy and material. In our last section, we describe new research directions for CIE pedagogy and explore how computing and information technology can support CIE teaching and learning.

Computing and Information Ethics Education: Foci

CIE foci include concerns about who in our in our information-centric world has a right or duty to create, provide, own, access, use, transform, manage, or govern various types of information. Foci also include thinking about the consequences of creating, providing, owning, accessing, using, and transforming information (Bynum 1985, Johnson 1985, Moor 1985, Mason 1986, Weiner 1954) as well as discussions about the rights and responsibilities of individuals, groups, and societies as they interact with information. Finally, CIE foci include issues of equity, care, and virtue as information is used to transform our world.

Does anyone who creates a computer program have the right to accrue economic benefits related to the use of that program? Should the program be owned by society? What best serves the individual and society? Does an economically disadvantaged youth from an urban area deserve the right to use the Internet in order to learn? If so, what responsibilities do governments, corporations, not-for-profits, you as an individual, or we as a society have to provide this access? What responsibility do we have to support access to information for individuals in China?

Alternatively, is the Chinese government's censorship of the Internet appropriate? Or considering another CIE domain: How can or should a multinational corporation based in the U.S. support the right to earn a living in an information economy for Indian (non-U.S.) citizen software engineers while concurrently maintaining its commitments to U.S. employees? Finally, in a last example CIE domain: When are the social benefits derived from use of private personal information appropriate?

These are just some of the questions considered in CIE. Is there one answer to each question? Or are there multiple answers for different people and situations using various techniques and criteria? To introduce the reader to information ethics, and its importance to society and individuals, we discuss three currently unresolved CIE issues: 1) who should control procedural information (software)—information ownership, 2) who should control personal information—information privacy, and 3) how can software and data quality be broadly accepted as a CIE issue and enhanced.

Information Ownership

> "In the information age, there may be no more contentious issue than the scope of ownership rights to intellectual property" (Spinello and Tavani 2004, p 247).

Intellectual property (IP) is an idea, invention, process or other form of property created by use of the mind or intellect; alternatively, IP is control over the tangible or virtual representation of those forms of property. The argument for the ethical appropriateness for intellectual property and legal supports (e.g. trade secrets, trademarks, copyrights, patents) follows.

Software is invaluable to our information economy. The development of unique software that solves problems is intellectually involved and time consuming, therefore the first unit of software is very expensive. However, due to the low cost of media and hardware such as compact discs (CDs) and personal computers (PCs), copies of that software [which can be readily shared] are very inexpensive. Individuals and corporations will not invest in developing new software, if return on investment supported by control of leasing or sale of the software is not provided by governments, in the form of copyrights, patents, etc. When individuals and companies do not create software, the economy and society are deprived of the benefits of new software products.

However, some individuals and corporations interested in robust, need-fulfilling software [as opposed to interest in software because it is a commercial product that leads to corporate revenue] have adopted a new approach, known as open source development. Open source development shows that software can be developed with the same quality as that developed under intellectual property protections (Mockus et al. 2002). One argument for open source follows: Software essentially provides a service to those using the software. Intellectual property laws however focus companies on the development of software, as opposed to the support of software (a service). The continuing support of software (patches, upgrades, training) is essential to software fulfilling the purpose that it was leased or purchased to perform. Because legal mechanisms related to intellectual property such as patents and copyrights ensure economic benefits to software companies via the non-introduction of similar products and services, software companies have no incentive to provide strong support service (in terms of help desks, bug fixes, new versions, etc.). Simply put, software companies that receive incentives (such as IP protections) to invent but do not receive incentives to provide support after the sale will naturally put most of their effort towards invention (Quinn 2006c, p. 188). As a result, companies that paid for software may not be able use software to its fullest extent, even though new types of software are developed often.

Further, the benefits of open source code development are: Users (who are very knowledgeable about their needs) are able to improve the software by fixing bugs and creating new functions. Because *users* are involved, more people are working on the code: when more people work on the code, it evolves more quickly.

From another perspective, since there are no copyright laws or patent infringements under open source, users don't need to worry about the conflict between choosing to 1) pirate software, perhaps in pursuit of another objective that is ethical or 2) not pirate software, but also *not* do something that is ethical (e.g., caring). An example of an ethical purpose that could be fulfilled by [illegal] pirating (sharing a copy of software and allowing another to install your licensed version of the software) would be to help a small nonprofit organization generate managerial reports that will be used to improve organizational effectiveness, and consequently help society. If the software were used, the not-for-profit will be more effective in its mission. To some, the *less* ethical solution would be to choose to not pirate the software and consequently not help the nonprofit by following the law. A free open source accounting system avoids this ethical dilemma between following the law and doing something caring.

Another benefit of the open/community source paradigm follows. Since the user-base "owns" the software, as long as the user-base is interested in maintaining and evolving the software, the software remains available. With commercial software, if the company that "owns" the software, and licenses it to users decides to stop evolving or supporting the software, the user company is caught in a difficult position, because the user company will have to *independently* try to maintain or create new versions of the software, (*if* it can obtain the proprietary source code) as opposed to the software company that holds the copyright or patent (Quinn 2006c, p. 189-190). To compound these issues, in the case of commercial software, the user company is *inexperienced* in supporting the software because, under the commercial software system, the software had been maintained by the company that created the software. If the user company cannot support and evolve the software, it will be forced to purchase other commercial software and re-train its employees, at significant cost. If open source software is used instead of commercial software, these issues do not arise, because the software's source code is maintained cooperatively across many user companies in the open source community, is available, and the user company has experience in fixing or updating the software's source code.

Some organizations, because of the reasons just cited have embraced open source. The Sakai community (a consortium of universities and colleges) has developed educational software to support electronic learning. These universities found that available commercial software products did not fulfill their educational needs (i.e., the software was not reliable, did not evolve quickly, and was not adequately supported). Their success has been so clear that some of the participating universities are considering starting open source projects for their financial systems (Baron 2006). The question about who should "own" software remains open.

Information Privacy

> "Our challenge is to take advantage of computing without it taking advantage of us." (Moor 1997).

CIE not only considers who should control software (procedural information) and reap its benefits; it also considers who should control personal information, and who may be hurt when it is possessed/used by the wrong parties. Consider how each of the following items allows someone or some group to capture and store information, which can subsequently studied, and how these actions may affect our privacy: Commercial and government databases; data mining; radio frequency identification; transportation, mall, and cell phone cameras; key, membership, and credit cards; GPS; ATMs; cookies; thumb print readers; and facial recognition systems.

Information professionals are called upon to support this infrastructure daily. How they support this infrastructure is not simply technical but also ethical. Where is surveillance appropriate? How should surveillance targets be notified? Should data from two different types of sources be combined easily—especially when it makes individuals vulnerable? For example, if one types a person's phone number (found in a telephone book or on http://whitepages.com) into http://google.maps.com one can find the directions to that person's home. How can we forecast prospective personal damage from such combinations? When information is used, and people are hurt, who is responsible? While some research has sought to explore the balance between the needs of the person for control of their information with the needs of society for commerce and security, the questions are still very open (Hodel-Widmer 2006). The globalized economy and multicultural society (with varying emphases on particular values such as individualism or collectivism) create further disagreements regarding privacy (Capurro 2005). Society needs to handle information about individuals carefully. While academic, political, and legal arenas are helping with privacy-related strategy and policy, the operational aspects of privacy fall squarely on information professionals.

Information Quality

The final example CIE issue discussed here involves questions about the quality of procedural information (software) or declarative information (data). Software quality includes the degrees of reliability, reusability, and configurability that characterize a particular software package. It also includes considerations such as levels of robustness, performance, recoverability, flexibility, and portability. Dimensions of data quality include how accessible the data is (for example, for handicapped individuals). It also includes how interpretable, how complete, or how objective the data is. Other data quality categories include data value, consistency, and accuracy. (Fisher et al. 2006, p. 43). It has been shown that poor quality of information software systems has caused loss of life. One example is the Therac-25 electron accelerator accidents:

> "Between 1985 and 1987, six accidents involving Therac-25 machines occurred in the United States and Canada. These accidents produced large patient overdoses that resulted in four deaths and two serious injuries. The accidents were caused by a series of factors including two errors in the software" (Birsch 2004, p. 241.)

It has also been shown that poor quality information systems data has caused loss of life; for instance the *USS Vincennes*/Iran Air Flight 655 disaster, that resulted in 290 passenger deaths (Fisher and Kingma 2001). On July 3, 1988, a team aboard the *USS Vincennes*, an anti-air warfare cruiser, using the Aegis battle management system, on its Captain's order, shot down Iran Air Flight 655 (an Airbus passenger aircraft), believing it was an attack aircraft.

Fisher and Kingma (2001) explain how data quality (inconsistent data) played a role in the disaster. One major issue was that the software recycled a set of identifiers for aircraft presented within the user interface. The identifier TN4474 was used twice; once for the airbus

(Flight 655) and once for an attack aircraft (an A6 Intruder). Flight 655 was subsequently assigned TN4131. The captain asked for the status of TN4474 and was told it was an attack aircraft; but the crew had been discussing Flight 655. The *Vincennes* crew subsequently then shot down Flight 655. The quality of the data was inconsistent; leading to confusion as to which aircraft should be targeted.

Another issue with data quality in the *USS Vincennes*/Iran Air Flight 655 disaster was that the data the crew and captain received was incomplete: White half-diamond “dots” indicated hostile aircraft; White half-circle “dots” identified friendly aircraft; White lines projecting from the dots indicated course and speed. Using relative length of these white lines to indicate speed hampered using relative length to indicate aircraft size; therefore the users were unable to distinguish the difference between an Airbus and an attack aircraft. Note that the quality of the data identified by Fisher and Kingma (2001) as poor was actually presented by software that had poor quality as well.

These three sample CIE foci (information ownership, privacy, and quality) can be affected by information professionals or users, and hence, society. Finally, future computing and information professionals will face new types of CIE problems. For example, they may resolve issues that arise when humans become increasingly more dependent upon embedded-within-the-human artificial systems. Current examples include cochlear implants, cardiac defibrillators and pacemakers, and robotic limbs. In the future, it is not unreasonable to expect that more technology will be used by and attached to the human body, much as these are today. As this occurs, it seems likely that individuals will use information ethics in order to deal with issues raised by medically-oriented information-intensive body extensions or replacements.

This is not the only potential CIE domain. If and when autonomous machines surface, CIE will become especially important (Moor 2006). Thus, as the speed of [information-oriented] technological change increases, developing an understanding and appreciation of and solutions to CIE issues are clearly of significant and increasing importance to society. As a result, it is very important that the educational experiences of computing and information professionals include a sufficient preparation in methods to consider CIE issues.

Computing and Information Ethics Education: Approaches

Why is computing and information ethics education important and how should it vary?

In order to describe one ethical problem solving domain, we present a potential ethical scenario for a professional software engineer:

> *Imagine that you are a computing or information professional with a consulting business that helps other companies develop new software products. You have just accepted a contract with a software company, based in Greece, to assist in the development of a software product. Early on, you discover that their software appears to violate the patent of a rival company, based in India, whose software you are also involved in developing. How can you resolve this situation to protect the interests of both of your clients without violating 1) the non-disclosure agreements that you signed with each of these companies, 2) your professional code of ethics, or 3) your own personal sense of integrity?*[1]

This situation presents the reader with a potential ethical conundrum for a software engineer, related to intellectual property, and within an international context. Unfortunately,

[1] This case excerpt was adapted from Burmeister (2000).

computing and information professionals are ill-equipped in practice to deal with such scenarios. For example, Chuang and Chen (1999) found that in four different countries, including the US, computing and information professionals do not have sufficient educational opportunities to learn about CIE. It is important that students not only have the opportunity to learn about CIE, but also that they are exposed to a wide range of ethical perspectives (Clarkeburn et al. 2003). Computing and information professionals must be provided not only with technical training but also ethics education to prepare them to deal with CIE issues such as information ownership, privacy, and quality within an international context.

Teaching courses in CIE as part of information technology, systems, studies, science, management, and policy as well as computer science education programs is essential to deepen and broaden the ethical problem solving abilities of computing and information professionals. However, these ethical problem solving abilities are ultimately applied in different domains. While computer science graduates develop software, information systems graduates design/install software. Although information technology graduates administer software, information science graduates support others' search and access to information. Finally, information management students enable their organizations' use of information and information policy graduates suggest best uses and methods to support use of information. Therefore it is important that each of these types of programs tailor their education accordingly.

What has been done?

CIE education has been built upon the work of pioneers such as Walter Maner (1978/1980), Terrell Bynum (1985), James Moor (1985), and Deborah Johnson (1985). Walter Maner, when teaching a medical ethics course, realized that the computer could affect ethics decisions in medicine (Bynum 2001). He subsequently self-published *A Starter Kit for Teaching Computer Ethics* in 1978. As Maner marketed and made his starter kit known, he convinced Terrell Bynum of the efficacy and importance of computer ethics. In 1983 Terrell Bynum as the editor of the journal *Metaphilosophy*, held an essay contest focused upon computer ethics. The winner of the essay competition was James Moor, with “What is Computer Ethics?” (Bynum 2001). Also, in 1985, Deborah Johnson wrote the first textbook in computer ethics, entitled *Computer Ethics.*

Since the founding of CIE (then, and sometimes still called, “computer ethics”) education, an increasing number of scholars have contributed knowledge. In 1991, the Association for Computing Machinery (ACM) and the Computer Society of the Institute for Electronics and Electrical Engineers (IEEE-CS) published *Computing Curricula 1991*. Within the “Underlying Principles” section, and in its “Social, Ethical, Professional Issues” section, it suggested that:

> “Undergraduates also need to understand the basic cultural, social, legal, and ethical issues inherent in the discipline of computing…Students also need to develop the ability to ask serious questions about the social impact of computing and to evaluate proposed answers to those questions. Future practitioners must be able to anticipate the impact of introducing a given product into a given environment. Will that product enhance or degrade the quality of life? What will the impact be upon individuals, groups, and institutions?...Future practitioners must understand the responsibility that they will bear, and the possible consequences of failure…To provide this level of awareness, undergraduate programs should devote explicit curricular time to the study of social and professional issues.” (*Computing Curricula 1991*, Section 5.3)

This guideline provided much detail as to why ethics was important to the graduating undergraduate computer science major.

In 1994, the National Science Foundation funded a 3-year Project on the Integration of Ethics and Social Impact Across the Computer Science Curriculum. Its first report (Huff and Martin 1995, Martin et al. 1996a) reported the creation of a conceptual framework for undergraduate CS ethics education and identified ethical principles and skills that a computer science undergraduate should incorporate and develop.

The second report, (Martin et al. 1996b), outlined a complete knowledge area that should be taught to undergraduate CS students; this knowledge area described coverage of five educational units that addressed the principles and skills identified in Report 1. It also suggested strategies for incorporating the material into a CS curriculum, for example via a course on computers and society or in a capstone course. The second report also spoke to actual techniques that could be used by instructors in the classroom. In its third report (Martin 1999, Martin and Weltz 1999), the group presented in-depth models of how to integrate the material developed throughout the project across the undergraduate CS curriculum.

Another group that developed goals and standards for CIE education was the Social and Professional Issues Knowledge Area Focus Group of the ACM/IEEE Computer Curriculum 2001 effort. Computing Curricula 1999 was an initial step towards suggesting discussions of the social context of computing, responsibilities of the computing professional, and intellectual property. Computing Curricula 2001 identified and suggested many more facets of CIE, such as making and evaluating ethical arguments, identifying assumptions and values, and using moral philosophic theories such as utilitarianism or the Categorical Imperative. It also discussed CIE applications areas such as information privacy, computer crime, etc.

At this same time, as these projects were developing CIE pedagogy, non-computer science information-oriented schools began considering information ethics (Carbo and Almagno 2001, Froelich 1992, Hauptman 1988, Koehler 2003, Kostrewski and Oppenheim 1980, Samek 2005, Severson 1997). Management scientists identified major information ethics issues. For example, Richard Mason described four ethical issues of the information age: privacy, access, property, and accountability (1986). Others began work on how organizational information systems provided the environment for ethical dilemmas and made this work available to educators (Paradice and Dejoie 1988, Mason et al. 1995).

In addition to this work, many other resources were developed. They include websites such as ComputingCases.org, the Online Ethics Center for Engineering and Science (http://onlineethics.org), and Ethics In Computing (http://ethics.csc.ncsu.edu/); organizations such as the Electronic Frontier Foundation, the Centre for Computing and Social Responsibility, and the International Society for Ethics and Information Technology; conferences such as ETHICOMP and Computer Ethics: Philosophical Enquiry; and journals such as Journal of Information Ethics and Ethics and Information Technology.

Where are we now?

CIE educators and researchers have made significant progress in CIE education delivery. The most recently published study on computer ethics education involved interviews with representatives from fifty of the two hundred four-year undergraduate computer science programs in the United States (Quinn 2006a). Thirty percent of these departments meet their need to provide CIE education by including discussions of social and ethical issues of computing within courses not primarily centered upon CIE, such as introductory or capstone courses (Quinn

2006a, p. 336). Fifteen percent of the departments require students to take an ethics course from another department (usually philosophy). Fifty-five percent of the departments require CS majors to take a ‘social and ethical issues of computing’ course from the CS department; in most cases this is an upper level course that is worth three credits (Quinn 2006a, p. 336.) Unfortunately, many respondents indicated the reason they include ethics within the curriculum is to pass accreditation—not because of an earnest belief in the importance of CIE education (Quinn 2006a).

Another recent study involved a survey returned by sixty of the 167 schools that teach Management Information Systems or Computer Information Systems (Towell et al. 2004). This group includes primarily “information systems” programs as compared to computer science or information science programs. The top methods used to teach CIE in these schools were: case studies (56.3%), personal experiences (54%), readings (41.4%), codes of ethics (28.7%), guest speakers (18.4%) and research papers (10.3%) (Towell et al. 2004, p. 294, Figure 1).In terms of the distribution of ethics within the curriculum the responses were: minimal coverage (40.2%), focused in a few courses (24.1%), woven throughout courses (16.1%), focused in a single course (10.3%), and largely ignored (6.9%).

Finally, in the field of library and information science, a recent study of forty-nine graduate programs accredited by the American Library Association found only sixteen actively taught courses that focused primarily on addressing information ethics issues (Buchanan 2004). These courses addressed “major ethical issues such as privacy, censorship, aspects of intellectual freedom, and the information rich and poor” (Buchanan 2004, p. 56). In terms of teaching methods, “most classes embraced a multi-method approach of lecture, discussion, and case analysis, with the readings as the basis for departure” (Buchanan 2004, p. 58).

Other issues for CIE education include computing and information faculty not feeling qualified to teach CIE (Quinn 2006b). Courses outside of the CS or IS department (e.g., philosophy) often don't provide opportunities for computing and information students to practice applying ethics to CIE issues (Quinn 2006b). Finally, in the case where there are specialized courses in CIE, the focus is typically on basic moral philosophies such as the Categorical Imperative or Utilitarianism, codes of ethics, and a few quintessential CIE cases (Quinn 2006b). However, CIE issues can be resolved using many complementary approaches: normative philosophical theories, specialized normative philosophical theories (Smith 2002), and descriptive models (Robbins 2005). Finding and using previous similar cases (McLaren 2006), referencing, interpreting, and using professional, industry, or corporate codes of ethics and conduct also supports considering CIE issues (Smith 2002). Finally, CIE issues can also be resolved by looking at one's own and others' values, experiences, perspectives, and concurrently exercising complex problem solving (Robbins and Hall 2007). This complex problem solving happens on at least two levels: within the individual's cognition and in groups of individuals' discussions. In order to engage students when teaching CIE, we should continue to develop our knowledge about how all of these methods can be used effectively. Other research areas include the use of computing and information technology to teach CIE.

Computing and Information Ethics Education: Research Directions

Pedagogical Research

To ensure that we provide the highest quality of CIE education to future computer and information professionals, we need to create innovative approaches to CIE education and empirically evaluate their effectiveness. For example, Huff and Frey (2005) integrate research from moral psychology with ethics pedagogy. One interesting aspect they outline recognizes that there may be two types of cognitive processes. One [unconscious, intuitive] process is quick to suggest action, but modifies itself very slowly, and the result of the process is a firm, internalized feeling about an issue (Huff and Frey 2005). Another [conscious, reasoning-oriented] process is slow relative to its counterpart, but can adapt to changing circumstances. Individuals in moral dilemmas apply both; first the intuitive process leading to a judgment, followed by conscious reasoning. Huff and Frey further indicate that adjustment of the intuition (e.g, learning) is better obtained via analogical, metaphorical, and narrative argument, than by rule-based reasoning. Based on their understanding of moral psychology research, Huff and Frey (2005, p. 395-396) suggest that ethics education, primarily through cases, sometimes with role-play, should support students:

1. Mastering knowledge about applying basic and intermediate ethical concepts.
2. Taking the perspective of the other as well as generating novel solutions to problems.
3. Learning how to sense problems.
4. Adopting professional standards.
5. Becoming part of an ethical community with other individuals.

Keefer in his *Science and Engineering Ethics* article (2005) reports his study of the processes used by students and ethicists (experienced ethical problem solvers) as they resolve [posed] ethical dilemmas presented as cases. Keefer studied how students and experts resolved the problems, and identified three methodologies; application of a principle or rule, study of consequences of alternatives, and use of role-specific obligations to when considering the problem. The study found that students who developed complex answers used role-specific obligations only or primarily, with principle- or consequence-based analyses. It also found that students who used principles/rules and consequence-based analyses perceived the problem to be a decision where one alternative was chosen, at the exclusion of other options, and that those that used the role-specific obligation technique created multi-dimensional solutions to problems. Finally, it found that ethicists almost exclusively used role-specific obligations to develop their answers. These ethicists also developed solutions that were stronger than students. This work shows that development and use of cases in education should be careful to support multi-dimensional solutions and help students think about professional role-specific obligations.

Weber (2005), based upon experiences in the classroom, suggests that pedagogy should vary based upon students learning styles and personality traits. One categorization of learning styles is the following: Visual, Aural (or auditory), Read/Write, and Kinesthetic. Visual learners learn by viewing graphical representations; Aural learners learn best in lectures; Read/Write learners take in and process information by reading and writing; Kinesthetic learners need to "do" the task (Lujan and DiCarlo 2006). He also suggests that learners be part of the process of selecting what is studied or how to learn. Weber also focuses upon the need to support inductive learning actively in the student, but with subtlety by the instructor. Instructors should not provide answers, but instead let students know when there may be incomplete analyses. Weber also suggests transparent pre- and post-measurement so that positive, reflection-supporting feedback can occur. Finally, Loui (2005) provides four examples of good practice: parsing a large problem into "bite-size" pieces, adjusting presentation of material based on interactions with students, use of active learning, and facilitating student cooperation.

What pedagogical CIE education research still needs to be done?

To achieve this new type of learning, CIE education researchers should apply (and empirically validate within the CIE education domain) findings from the field of learning science (Bransford et al. 1999, Sawyer 2006). This view on learning has developed as a result of advances in information about memory and knowledge, problem solving and reasoning, meta-cognitive processes such as explaining to one’s self, and scientific knowledge about community and culture (Bransford et al. 1999).

This new science has and is developing suggestions for learning and transfer, design of learning environments, and effective teaching. In terms of learning and transfer, these researchers have found that helping students understand *how* they learn helps these same students learn (Bransford et al. 1999: Learning and Transfer). Learning environments have been shown to be more successful when 1) educators know what the learner knows and understands—prior to teaching/learning, 2) the curriculum is a very structured, 3) assessments tied to learning goals are performed frequently to provide learner feedback, and 3) a learning community exists; where norms that reflect the importance of learning, high standards, and reflection and revision are fostered (Bransford et al. 1999, Sawyer 2006). It is now known that effective teachers "understand in a pedagogically reflective way; they must not only know their own way around a discipline, but must know the 'conceptual barriers' likely to hinder others" (McDonald and Naso, 1986, p. 8, in Bransford et al. 1999, Chapter 7).

In order to develop an improved environment for CIE education, it is important to understand the relationships between pedagogical materials used, teaching techniques used to transfer information and skills as students learn, and outcomes for CIE education. Many researchers have provided reports of their experiences with materials and techniques. Thus, many teaching materials such as e.g., ComputingCases.org, Online Ethics Center for Engineering and Science, Ethics In Computing exist Researchers have suggested techniques that include student role playing, heavy use of the blackboard, using surveys to involve students, and teachers managing discussions carefully (Quinn 2006a, 2006b, 2006c; Greening et al. 2004; Muskavitch 2005). Groups have provided curricula standards which outlined outcomes (*Computing Curricula 1991, 2001: Project Impact CS Reports 1, 2, 3)*. Researchers have reported outcome assessment methods (Sindelar 2003). However, the CIE education research literature has not shown or discussed the importance of the *relationships* between types of students, kinds of teachers, pedagogical materials, teaching techniques, learning processes, and outcomes. Integrated knowledge such as this could support an instructor that is attempting to help a student who values openness learn how to consider information privacy using the most effective technique. Perhaps iterative role play with fellow students would demonstrate to the student the potential societal benefits of using personal information where questions of privacy may arise.

To support the development of this knowledge, it is important to understand the processes used by people as they solve ethical problems. Better yet, it is important to understand how different types of people (e.g., those with varying values) use different processes. Unfortunately, very little is known about the processes that people generally, or students particularly, use when they solve ethical problems. Keefer (2005) has done some of the first work in this area, by extending Rest’s Four Component Model (1986) to seven components.

The processes people use to solve ethical problems are related to values or other personal characteristics. If we know an individual’s characteristics, we can know what processes are likely to be preferred (Robbins 2005). If we know what ethical problem solving processes are preferred, then we may be able to enhance these processes or teach new ones. Robbins and colleagues identified 22 relationships between value [types] and reasoning heuristics (which support processes), 28 relationships between reasoning heuristics and decisions, and 18 relationships between value [types] and decisions within a particular ethical dilemma. Values are "concepts or beliefs about desirable behaviors or end states that transcend specific situations, guide selection or evaluation of behavior or events, and are ordered by relative importance" (Schwartz and Bilsky 1987, p. 551). Reasoning heuristics are rules of thumb used by individuals that are considering an ethical dilemma. Decisions, in this context, are actual components of an overall solution. Unfortunately, because of space limitations, these relationships cannot be described here. However, this work is important because it shows that this kind of information can be captured so that [eventually] teachers and students can begin to understand reasons why other individuals approach resolving ethical dilemmas as they do.

Further, Fleischmann and Wallace have examined the role of human values in computational modeling. Specifically, Fleischmann and Wallace focus on how human values influence and are influenced by the use and design of computational models, how human values shape and are shaped by professional and organizational culture, and how these values determine and are determined by the success of the computational modeling process and of computational models as products. This project builds upon earlier collaborations on the importance of transparency in the design and use of computational models (Fleischmann and Wallace 2005) and the ethics of modeling (Wallace 1994, Wallace and Fleischmann 2005). The findings of this ongoing study (Fleischmann and Wallace 2006, 2007, in press), which adopts a case study approach to data collection and analysis, demonstrates the importance of understanding ethics and values for a specific subsets of computing and information professionals. Further, these results demonstrate that current educational efforts are not sufficient, as computational modelers (a type of computing and information professional) feel that they have not had adequate opportunities for ethics education in their past experiences in computing and information degree programs.

Research towards using innovative technology to support CIE education

CIE education does not only have to occur traditionally; it may be supported using modern computing and information technology. Some computer programs have been developed to help students and others understand and appreciate ethics (e.g., Goldin et al. 2001, Gotterbarn 2004, Maner 1998, McLaren 2006, Sherratt, Rogerson and Fairweather 2005, van der Burg and van de Poel 2005). For example, Interactive Computer Ethics Explorer (Maner 1998) leads the user through questions and shares summary information regarding answers from previous participants. The Professional Ethics Tutoring Environment (Goldin et al. 2001) helps a student analyze a case in a guided step-by-step manner. Agora (van der Burg and van de Poel 2005) provides structure to ethics courses by providing a portal that instructors can use to present cases that are then considered by students. Finally, Sherratt, Rogerson and Fairweather (2005) built a case-based aiding system for information and computing students that uses a decision tree paradigm that considers ethical domains, professional duties, and personal oral duties to find similar cases that students can use when analyzing an ethical dilemma.

Robbins and colleagues developed and assessed a decision support system that helps a student consider an ethical problem from new and different perspectives (Robbins, Wallace, and Puka 2004). The primary goal of the research was to show that information technology can be used to support ethical problem solving—as opposed to building a theoretically correct or complete ethics decision support system. The decision aid is web-based and provides content that summarizes and simplifies five example moral philosophies (selected to provide a wide range of perspectives): the ethic of care (Gilligan 1977), egoism (Rand 1964), virtue ethics, the Categorical Imperative, and utilitarianism. Other approaches, such as those offered by religious leaders, or the many philosophers not represented, could, at some future point be included within decision aids of this type. The intent was to make the simplified and presented philosophies transparent, as suggested by Fleischmann and Wallace (2005), in order to make the philosophic theories more accessible. The specific ethical dilemma used was the Pharmanet case (Chee and Schneberger 1998), which asks a reader to consider how to handle the prospective implementation of a widely accessible database of pharmacy prescription records. The ethics decision aid also helps the user understand the relationships among value types, ethical ideology dimensions, reasoning criteria, and decisions made when resolving an ethical dilemma (Robbins 2005). Robbins and colleagues concluded that web-based ethics decision aids can be built and used to improve the decision-making of students confronted with case-based dilemmas in a laboratory environment (Robbins et al. 2004).

New Directions

While each of these information systems makes significant contributions to computer-based ethics education, new directions remain.

> **Direction 1:** Since these systems tend to have static html-based interfaces that do not vary based on user’s actions, one fruitful direction would be the development of a dynamic system with the potential to embed more interactivity through the use of a more complex programming language such as Java. One of the most important benefits of

having a dynamic system is that it supports interaction and iteration, which in turn supports reflection and revision of knowledge.

Direction 2: Most of these systems are built solely for individual use and decision-making, leaving opportunities for designing systems that allow groups of users to collaborate, or for individual users to interact with intelligent agents, which could demonstrate how ethical decision-making is a social process. Computational models will support these new dynamic systems. The following indicates are computational models are being used to improve learning.

> "As scientists continue to study learning, new research procedures and methodologies are emerging that are likely to alter current theoretical conceptions of learning, such as computational modeling research. The scientific work encompasses a broad range of cognitive and neuroscience issues in learning, memory, language, and cognitive development...The research is designed to develop explicit computational models to refine and extend basic principles, as well as to apply the models to substantive research questions through behavioral experiments, computer simulations, functional brain imaging, and mathematical analyses. These studies are thus contributing to modification of both theory and practice. New models also encompass learning in adulthood to add an important dimension to the scientific knowledge base." (Bransford et al. 1999, Chapter 1)

In these veins, and beginning to address Direction 1: (Moving from static systems that do not vary by individual to dynamic systems that take user's personal characteristics and processes into account) and Direction 2: (Moving from individually-centered systems to collaborative socially-focused systems) Robbins and Wallace have designed, developed, verified, and validated a computational model of a group of software agents solving an ethical problem (Robbins 2005, Robbins and Wallace 2007) based on the study of groups of students solving ethical problems as well as students solving problems in isolation. For these studies the software agent paradigm was used in tandem with the concept of practical reasoning (Wallace 2001). In the context of artificial intelligence, an agent is a computer system that is capable of autonomous action and that interacts with other agents. Resolving ethical problems requires considering criteria, autonomy and sometimes, interaction. Software agents can consider criteria, act autonomously, and interact with other agents (virtual or human).

This research demonstrated that a software agent can mimic the practical reasoning-based resolution of an ethical dilemma (Robbins 2005). Furthermore the software contained agents based upon actual people that were studied empirically. These types of agents could be part of ethics education systems of the future. The multi-agent work of Robbins and Wallace particularly supports interaction with a group of individuals (Direction 2: Moving from individually-centered systems to collaborative systems) because using multiple agents supports multiple dynamic user profiles, multiple virtual actors, etc.

Also, supporting Direction 1 and 2 concurrently, Fleischmann demonstrates that human values play an important role in the design and use of two additional information technologies: educational simulations (Fleischmann 2003, 2004, 2005, 2006a, 2006b, in press) and digital libraries (Fleischmann 2007, in press, Jaeger and Fleischmann in press). This research identified online versus face-to-face use and individual versus group use of educational simulations as important areas for additional research. It also emphasizes the importance of face-to-face collaboration in educational simulation use (Fleischmann 2005).

Other research areas may be integrated with other CIE education research to support Direction 1 and 2. For example, towards fulfilling Direction 1 (changing from static to dynamic use) TRUTH-TELLER (McLaren 2006) compares two cases, and helps users identify similarities and differences. SIROCCO (McLaren 2006) analyzes the relationships between facts of cases and general principles and outputs a list of possibly relevant ethics codes and cases. Harrer, McLaren, and colleagues (2006) have also recently approached learning by individuals in groups by focusing on supporting a group of students solving a problem collaboratively, using a software-based cognitive tutor, fulfilling Direction 2 (changing from an individual ethical problem solving-orientation to support for social ethical problem solving (Harrer et al. 2006)).

Conclusion

In a world that becomes more and more dependent upon information and the computing devices that support this information, it is important that individuals who provide, own, access, use, transform, manage, or govern information are knowledgeable about and act according to proper moral considerations. Ethics includes considering the rights of others, consequences of one's actions, and fairness; it also includes caring and fulfilling one's duties in the best manner possible. CIE education is relatively young; and has been around for about a quarter century. CIE education can be improved by developing an integrated understanding of the inputs, processes, and outputs of learning as well as ethical problem solving. Further, CIE education can be improved by using new computing and information-based technologies.

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Terms:

Computing and Information Professionals: Individuals who [using computers] create, provide, own, access, use, transform, manage, or govern information.

Computing and Information Ethics: Resolving issues about the rights and responsibilities of individuals, groups, and societies as they interact with information. It includes issues of equity, care, and virtue as information is used to transform a world that is very dynamic, interconnected, (d)evolving, multi-cultural, economically-disparate, and increasingly dependent upon information.

Computing and Information Ethics Education: Processes that help computing and information professionals learn computing and information ethics.

Computing and Information Ethics Education Research: Processes that discover knowledge towards improving computing and information ethics education.

Information Ownership: A domain within computing and information ethics; Arguments for various owners of information are considered. Current discussions surround whether software written by an individual or group (procedural information) should be owned exclusively by that individual or group as intellectual property, or whether software should be owned cooperatively among users, companies, or society at large.

Information Privacy: A domain within computing and information ethics; Arguments about when information about specific persons should be public are considered. A current discussion focuses on trade-offs between personal information privacy and national security.

Information Quality: A domain within computing and information ethics; Computing and information professionals must consider the quality of software or data they are creating, providing, owning, accessing, using, transforming, managing, or governing. Low quality software or data have led to loss of human life.