A Consideration of the Lasting Effects of a Course Introducing Ethical Issues in Computing

Daniel T. Joyce
Department of Computing Sciences
Villanova University
Villanova, Pennsylvania 19085, U. S. A.
daniel.joyce@villanova.edu

William M. Fleischman
Departments of Computing Sciences and Mathematical Sciences
Villanova University
Villanova, Pennsylvania 19085, U. S. A.
william.fleischman@villanova.edu

Abstract. We discuss the objectives of a course for computer science majors that introduces ethical issues in computing. In particular we are interested – as an exceptional matter – in the long term objectives. We pose and attempt to answer [or at least discuss] the following questions: What effects are we hoping such a course has on its participants five, ten, twenty years down the road? How can our contemplation of these issues inform our pedagogy? How can we design this course so that is has a lasting impact on the students?

Keywords: Computer ethics, Ethical questions in software engineering, Case studies.

1 Introduction

In the United States, Europe, and Australia it is now commonplace for there to be a course on ethical issues in computing curricula. Coverage of such topics is mandated by accreditation commissions and emphasized in curriculum models. Of all the courses in the computing curriculum, this course is unique, as it is the one course for which we are truly invested in its long term effects. Although we realize there is no way to measure the effect of any particular course far into the future, we are nevertheless greatly interested in designing this course so that the students carry lessons learned with them throughout their professional lives. In this paper we look at the objectives for this course and discuss ways to make the lessons last.

2 Course Objectives

The statement of measurable course objectives and subsequent reasoned efforts to evaluate progression towards those objectives has become the holy grail of higher educational assessment and improvement. For most courses in the computing curriculum the identification of such objectives is fairly straightforward, being tied to the ability to understand and classify problems, and choose and apply appropriate solution techniques. In the case of a course on ethical issues however, the task of defining objectives is not quite as straightforward.

Clearly one objective of the course is simply to identify the issues and their impact on individuals and society. Many students arrive at this course carrying naive assumptions that all technology is good. So one goal is to allow the students to recognize/admit that issues exist and that they are complex. However, this is not enough. During I ETHICOMP Latinoamérica, the workshop on computer and informational ethics organized as part of CACIC 2011 at Universidad Nacional de La Plata, Argentina, Simon Rogerson of De Monfort University, UK, repeatedly made this point: not only do we need to identify the issues, we need to solve them.

The Ethics Education Library [1] hosts education resources in engineering and the sciences. A search of its archives revealed twelve courses on ethical issues in computing. Eight of the syllabi listed course objectives. Restating the objectives using a common terminology and merging together related objectives produced the following list organized as a progression from the identification to resolution of issues. For each, we discuss briefly how often and in what form they appeared in the eight syllabi. In an informal way, the list provides some insight into the current status of the identification of objectives for courses in ethical issues in computing.

The objectives state that the students will

- learn the vocabulary of the area, understand the issues: each of the eight syllabi lists this as a course objective, with three of them actually listing in detail the specific issues such as privacy and confidentiality, proprietary rights, and technological dependence.

- understand the impact of technology and the effect of choices made by computing professionals on their customers and the world: six of the eight syllabi specifically mention this objective; clearly the need to break through many students' unquestioning acceptance of technology has been recognized.

- identify the ethical issues related to a given situation: two of the eight syllabi directly mention this goal and one of those states that students will analyze a real software system for a client; several other syllabi mention the analysis of case studies, and therefore most likely target this goal.

- analyze a given situation from multiple perspectives: three of the eight syllabi include the objective of in-depth analysis of an ethical situation, with two of those clearly indicating the use of formal approaches.

- identify a solution and/or means of preventing the reoccurrence of a problem within a given situation: four of the eight syllabi directly mention the identification of solutions – of course, as is true for all of this informal discussion of the posted syllabi, that does not mean the other four courses do not include coverage of this topic.

A complementary perspective concerning the objectives of courses on ethical issues in computing can be obtained by inspection of the collective wisdom about the subject incorporated in the recommendations of professional societies. The Criteria for Accrediting Computing Programs of the ABET Computing Accreditation Commission, effective for reviews during the 2012-2013 accreditation cycle, lists eight items under the heading of General Criteria, including one specifically labeled Student Outcomes [2]. In addition to stating that a program must have documented student outcomes and a documented, effective process for both reviewing and revising these outcomes, the Commission lists the following general outcomes that should be central objectives of any accredited computing program:

"The program must enable students to attain, by the time of graduation:
   a) An ability to apply knowledge of computing and mathematics appropriate to the discipline
   b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution
   c) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs
   d) An ability to function effectively on teams to accomplish a common goal
   e) An understanding of professional, ethical, legal, security and social issues and responsibilities
   f) An ability to communicate effectively with a range of audiences
   g) An ability to analyze the local and global impact of computing on individuals, organizations, and society
   h) Recognition of the need for and an ability to engage in continuing professional development
   i) An ability to use current techniques, skills, and tools necessary for computing practice."

Although at first glance it appears that only items (e) and (g) are related to ethical issues, we would argue that a closer and more nuanced look suggests that every item on this list is related to what should be regarded as ethical practice in the computing profession. The consideration/study/practice of ethics pervades every aspect of the curriculum of computing. In fact, one salutary purpose that should be served by a good course in computer ethics is to underscore this point by repeated reference to cases (for example, involving electronic voting technologies, life and safety critical systems like the Therac-25) where inattention (whether deliberate or through

oblivious behavior) to these items causes or portends harm to individuals or society as a whole. Clearly these instances can be identified as lapses in the ethical performance of professional duties whether by an individual or a collective.

The idea that objectives related to ethical issues cut across the entire CS curriculum is also promulgated by an ACM/IEEE-CS Joint Task Force which, at the time we are developing this paper, is working on Computer Science Curricula 2013. The current Strawman document for this updated CS Curricula lists 18 Knowledge Areas, including one, Social and Professional Practice, which contains sub-units such as Social Context, Professional Ethics, Intellectual Property, and Privacy and Civil Liberties [3]. The document strongly suggests a separate course be devoted to this Knowledge Unit although it also acknowledges that "an ethics-related module could be developed for almost any course in the curriculum."

3 Long Term Effects

Although computing program goals sometimes look several years into the future, for example by including sweeping statements such as "the students will become productive members of the discipline", specific course objectives typically are stated in terms of the knowledge and abilities of the students as they leave the classroom door at the end of the semester. For example, in the CSC 2013 Strawman document when it states that students will be able to "Understand the formal definition of big O" or "Explain why the halting problem has no algorithmic solution" the assumption is that these abilities exist within a reasonable time span after the course ends [3]. Achievement of the objectives might be evaluated by an end of semester test or even by a comprehensive exam taken a year or two after the specific topics were covered. No one however, would attempt to evaluate such objectives twenty years into the future. Just imagine a university representative entering the office of a senior software architect, long after this individual graduated from the university, and asking "please complete a formal proof of the fact that no algorithm exists which, when given a description of an arbitrary computer program, can decide whether the program finishes running or continues to run forever."

As educators we are usually not concerned about the status of our course objectives so far into the future. If one of our students ends up in a career which requires the use of knowledge/ability related to a specific course objective then she will not lose that knowledge/ability. For a student who takes a different career path, his retention of the knowledge/ability may not be important. This is where the objectives related to a course on ethical issues differ from many of the other course level objectives in computer science. Admittedly there is no way to measure the effects of a course on ethical issues, or any other course for that matter, twenty years down the road. There are so many variables that come into play once an individual has graduated from college, that it would be impossible to separate the effects of an individual course on graduates' beliefs or behavior from the many effects of twenty years of professional

and personal experience. Nevertheless we do work toward the goal that the effects of this course last.

Although it is likely that students' knowledge of the specifics of various ethical theories and command of some of the analytical tools may have a shorter half-life, we do want/hope/expect that our students, twenty years from now, will still remember the horror they felt on first reading of the grievous injuries and deaths that resulted from faulty engineering decisions made by the developers of the Therac-25 radiation therapy machine [4]; will still remember the shock of realization that technologies so familiar to them, so apparently beneficial, to which they have always had recourse without question or reflection, could be the source of serious harm to individuals and to society as a whole [5]; will still remember the lesson that projecting onto others the easy trade-off they are willing to make – relinquishing portions of their own domain of personal privacy in exchange for ready access to information and web-based commerce – can result in harm to others that is eventually reflected back onto them [6]; will still feel keenly the anguish he or she felt, sitting in the conference room with Roger Boisjoly at Morton Thiokol on the evening before the launch of the Challenger, knowing that an unacceptable and fatal decision was about to be made and that he or she was powerless to reverse it [7] (for this last point see the discussion in Section 5).

4 Which Themes Resonate with the Students?

In the Spring of 2012 we taught two sections of a course entitled "Ethical Issues in Computer Science". Across the two sections were a total of 54 students: 31 computer science majors for whom this course is required plus 13 engineers, 2 mathematics majors, and 8 students from the "arts". Although one of the course sections was offered during the evening, each section consisted primarily of traditional full-time students, ages 19 to 21. Depending on how sharply one wishes to focus the lens of inspection one could conclude that the backgrounds of these students are very homogeneous (most are upper-middle or privileged class, have a history of strong academic performance, and have been raised in a nurturing environment) or one could conclude that they are quite a diverse group (the better we get to know our students – and when teaching this course we get to know them very well – the more we realize that every young adult has his own unique interesting life story).

For pedagogical purposes we divide the course into eight major sections, although in reality the themes are all inter-related and during the study and discussions of each major theme, other related topics are discovered, investigated and woven into the fabric of the course. The major themes, along with their corresponding assigned readings, are:

1. What is Computer Ethics?
   - Moor: What is Computer Ethics? [8]
   - Barlow: Coming into the Country [9]
   - Gotterbarn: Responsibility Regained [10]

- Winograd: Computers, Ethics, and Social Responsibility [5]
- Weizenbaum: On the Impact of the Computer on Society [11]

2. Responsibility, Reliability, and Accountability
    - Leveson: The Therac-25 [4]
    - The Challenger Explosion
        - Davis: Thinking Like an Engineer [12]
        - Boisjoly: The Challenger Disaster [7]
        - Tufte: excerpt from Visual Explanations [13]
        - Nissenbaum: Computing and Accountability [14]
3. Privacy, Databases, and the World We Inhabit
    - Kerr: Updating the Foreign Intelligence Surveillance Act [15]
    - Bellovin, Blaze, et al: Risking Communications Security [16]

4. Ownership and Intellectual Property
    - Stallman: Why Software Should Be Free [17]
    - Raymond: The Cathedral and the Bazaar [18]
    - Lessig: Intellectual Property (chapter 10 of Code and Other Laws of Cyberspace) [19]
    - Boyle: several chapters from The Public Domain: Enclosing the Commons of the Mind [20]
    - Hardin: The Tragedy of Commons [21]

5. The Internet – Ecosystem and Governance
    - Carr: Is Google Making Us Stupid? [22]
    - Vaidhyanathan: excerpt from The Googlization of Everything [6]
    - Goldsmith and Wu: excerpt from Who Controls the Internet? [23]

6. Robotics, Artificial Intelligence, and Warfare
    - Singer: excerpts from Wired for War [24]

7. Electronic Voting
    - Rubin et al: Analysis of an Electronic Voting System [25]
    - Penha-Lopes: Why Use an Open Source E-Voting System? [26]

8. The Networked World
    - Forster, The Machine Stops [27]

In this section of the paper we try to discover which of these themes seemed to resonate most strongly with the students. We could simply recollect which topics seemed to generate the most animated class discussions; however that would possibly be skewed towards the opinions of the most vocal students. So instead we present the choices/replies made by the students towards the end of the semester when given the opportunity to reflect and discuss a topic of their choice.

Our grading scheme for this course is based on short response assignments, two papers, class participation, and two tests (including a final exam). For the second paper, due shortly before the end of the semester, the students were asked to choose a topic they wished to explore related to one of five indicated themes – a topic that we did not have sufficient time to develop during the regular flow of the course. The table below shows how many students choose to write about each of the themes for this assignment, broken down by gender and by major.

Theme	Total	Gender		Major		
		F	M	Computer Science	Engineering	Other
Privacy	8	3	5	4	1	3
Intellectual Property	9	2	7	6	2	1
Internet Governance	6	1	5	4	2	0
Robotics & Warfare	26	6	20	15	7	4
Electronic Voting	5	2	3	2	1	2

Note the popularity of "Robotics and Warfare" as the students' choice for this assignment. While it is tempting to state that the students were obviously engaged by this theme – and it does include much to capture their attention and spark interesting debate for example questions about the sanctity of life in a world where some machine does your killing for you while you sit at a console half a world away – it is also true that this was the topic covered most recently when this assignment was given and that could be at least part of the reason for its popularity. Also of note although hardly conclusive given the small number of "Other" majors (the non-computing non-engineering majors) we see that 30% of them chose the Privacy theme where-as only 9% of the computer science and engineering students did so. If nothing else this underlines the importance of trying to have a diverse audience involved in this course – we find that quite often the points of view brought to discussion by the non-technical majors are invaluable in broadening the conversation and allowing all the students to see things from multiple angles. We return to the importance of viewing things from multiple angles in the following section when we discuss our "triangulation" approach to topics.

Next we look at the students' responses to a final exam question which more directly addresses the topic of our paper. The question reads:

> "Ten years from now, what do you imagine will be the most important thing(s) that will remain with you from this course?"

We received a wide range of answers to this question. Some were philosophical, for example consider this excerpt from an answer given by a female computer science major who admitted that prior to this course she always just assumed that any technological advance was automatically "incredibly useful and life changing." She writes "I will never forget that we need to be careful with technology to make sure we don't lose what it means to be human ... I realize now that at a certain point technology isn't going to solve all of our problems and could in fact make them

worse". We estimate that about 40% of the responses included some sort of introspective philosophical angle to them.

Some of the responses were very practical, for example consider this excerpt from an answer given by a male computer engineering major who first mentions the effects of the discussions about the Therac-25 and Electronic Voting Machines had on him, writing that it made him realize "... how important it is to practice safe coding and to test my code as thoroughly as possible ... those two examples will stick with me so that my coding never becomes lazy". Again, about 40% of the responses mentioned some sort of practical lesson learned, one that the student says will stay with her in the future.

The remaining 20% of responses are impossible to categorize. In these responses the students report things such as "I really enjoyed the intensity of the class discussions" or "this course gave me a new way of looking at things". While these are good responses it is not possible to place them into one of the practical/philosophical bins, or to categorize them as referring to a specific topic area.

Looking at the answers to this question as a whole we notice that although all of the course themes are mentioned in one place or another, two topics are repeatedly emphasized by a significant number of students. Many of the students believe that due to taking this course they will:

- Use sound software engineering practices: This topic is referenced in some form by approximately half of the students. Threads of this topic are woven across the course, in particular when we discuss the ramifications of poor practices from several points of view in discussing the Therac-25 incident, the Challenger disaster, and the introduction of electronic voting machines. In their exam answers most of the students vow to remember the lessons learned from these case study discussions, to practice safe software engineering approaches throughout their careers, and to be careful about not allowing themselves to slip into apathy – to maintain diligence.

- Consider the potentially harmful effects of technology on our lives: Out of all the course topics we believe this is the one that "surprised" the students the most. This topic also crossed theme lines within the course, surfacing in different guises within the Privacy, Internet Governance, Robotic Warfare, and Networked World themes. Approximately one-third of the students included something related to this topic in their exam question answer. Most mentioned something along the lines of having had their eyes opened, about having not thought about the negative aspects of technology before, and expressing their hope that they can remember to consider both positive and negative effects when creating and using technology.

5 Course Approaches that Promote a Lasting Effect

There is an argument to be made that the objectives articulated in the syllabi archived in the Ethics Education Library [1] relate to theory and technique that have a relatively short "half-life" once students have graduated and embarked on their professional careers. This is not to dispute the place, in a course on computer ethics, of developing an accurate vocabulary, identifying ethical issues embedded in common situations, or applying analysis from multiple perspectives in order to describe possible solutions and/or means of preventing reoccurrence of undesirable outcomes.

Equally, Simon Rogerson's assertion that "not only do we need to identify issues, we need to solve them," finesses a very important point: There are instances in which the issue and the solution are fairly clear, but some essential precondition for actualizing the solution is missing. This is the case in the example discussed below where the "correct result" is quite clear but the real problem is how to arrive at the correct result in the face of a concerted power play brought to bear on subordinate engineers by their superiors. (Don't expect too much from the discussion. If we knew the means of unerringly reaching the correct result, we would already have been awarded the Nobel Prize in Computer Ethics. Maybe next year.)

Here is where an appeal to students' imagination can serve as a potent adjunct to theory and technique. In our experience, an exercise that engages the imagination – asking students to place themselves in the situation of one of the actors in a story of this sort; in effect, asking them to project themselves years forward into their professional lives or to inhabit the persona of someone whose circumstances are foreign to their own background and perspectives – is a means of underscoring the problematic aspects of the situation and producing a deep and vivid impression which is imprinted for the long run.

Perhaps the best example of this, taken from our practice, is the case of the Challenger explosion. We utilize a technique that we call "triangulation" in approaching the story of the Challenger. This involves having the students read three sources. The first of these is Michael Davis' paper, "Thinking Like an Engineer." [12] The second is an excerpt from Edward Tufte's book "Visual Explanations" [13] in which Tufte critiques the documents relating to the launch prepared by Morton Thiokol (MTI) engineers. The last of the sources is the first hand account of Roger Boisjoly, the MTI engineer who tried, unsuccessfully, during the months leading up to the ill-fated launch, to persuade his superiors at MTI to address the problem of loss of O-ring resiliency in cold weather conditions. [7]

Davis' paper takes as its point of departure an apparently accurate recital of a critical moment in the events of the evening preceding the Challenger launch [12]. Davis constructs a sermon, in the form of a logical argument utilizing the dramatic details of pre-launch conference call between the MTI engineers and the Marshall Space Flight Center personnel responsible for the actual launch decision, intended to inculcate the importance of engineering codes of ethics. This is a lesson to which our students are quite receptive however, as experience shows, too uncritically receptive. During

course discussions and based on responses to a written assignment this past semester we could see that most students naively believe "If only there had been a code of ethics in force on that evening, this particular tragic and very bad thing would not have happened." But of course there was a code of ethics in existence, the code of the Society of Professional Engineers, promulgated in 1967 [28], which almost certainly bound every engineer present in the room at MTI at the time of the conference call. Yet there is no record of anyone there being called to attention by means of reference to the fundamental principle of that code: that the professional engineer must "hold paramount the health, safety, and welfare of the public." Perhaps the first step in helping students cultivate an informed and realistic view of the true value of codes of ethics is to subvert the simplistic and uncritical "faith" in the power of codes of ethics with which they arrive in our classroom.

The reading from Tufte is more straightforward [13]. Tufte addresses the fundamental failure on the part of the authors of the documents supporting the "no launch" recommendation to illustrate clearly the relationship between launch temperature and O-ring damage on previous shuttle launches or to exhibit the more than three standard deviation gap between the anticipated temperature the following morning and the mean temperature for previous launches. He also notes the absence of any indication of authorship on the documents remarking that, "Public, named authorship indicates responsibility, both to the immediate audience and for the long-term record." [13] There is, perhaps, a concealed sermon in assigning this reading – one that we are not above articulating explicitly. Tufte's critique speaks to the importance of required or elective course work in statistics and data visualization. We often ask students whether these courses in our curriculum have truly measured up to the demands that will be made on students' mastery of this material. We exhort them to pay attention and to insist – for their own benefit – that these offerings be rigorous and substantial.

Reading Boisjoly's first-hand account completes the triangle and is clearly the crucial element in the strategy of engaging students' imagination [7]. In contrast to the readings from Davis and Tufte, the various episodes in Boisjoly's account are almost literary in their use of explicit and implied emotional markers. Here, students cannot avoid vicarious participation in the real drama of the evening prior to the Challenger launch. But there is also revealing drama in his account of the months preceding the decision to launch. The chronic frustration experienced by Boisjoly in his attempts to convince his supervisors to commit time and resources to investigate and resolve the problems associated with O-ring erosion during cool weather launches is one of critical factors that contributed to the psychological atmosphere that obtained among the engineers during the evening when the decision to launch was debated. Part of our strategy involves having the students step through this history – in the shoes of Roger Boisjoly – trying to have them recreate, in their own minds, the psychological state of someone in his position. This is the important preliminary step to having the students "re-live" the dramatic events surrounding the conference call which overturned the engineers' unanimous recommendation against going ahead with the launch in the cold conditions anticipated for the next morning.

So it is not simply a matter of reading the three sources. It is finally a matter of having the students come as close as possible to experiencing the excruciating discomfort of the MTI engineers during the discussion that led to the reversal of their recommendation – and then backing up through the history preceding the evening before the launch of the Challenger and trying to "see a way out" of what was a naked power play imposed on them at the last moment. In this process, we have occasion to refer to the provocative paper by Terry Winograd, "Computers. Ethics, and Social Responsibility," [5] in which Winograd presents the caricature of the "troupe of jugglers" to illustrate a process of engaged dialogue he believes will promote informed, ethical behavior on the part of those involved in making "spur of the moment" decisions with potentially serious consequences – a description that seems to map well onto the situation of the MTI engineers in the run up to the Challenger launch. The point of this approach, in the end, is not to suggest the existence of an easy solution to such a concerted power play, but rather to suggest that working to create an environment of collegial solidarity based on continuous dialogue and sharing of perspectives can provide a means of altering the course of events – in the most fortunate case creating a branching point well in advance of a dramatic confrontation while nonetheless fostering an awareness of solidarity among those of subordinate status that would increase the likelihood of decisive and courageous joint action should circumstances warrant it.

Naturally, such exercises need not have the sole purpose of showing the student an otherwise unobvious "way out" of a difficult professional situation. They can be used as well to point out problematic aspects of technology that affect all of us in our lives as citizens as well as professionals. For the past two years we have screened Florian Henckel von Donnersmark's film, "The Lives of Others," [26] to help our undergraduate students, whose appreciation of the value of personal privacy and the unhappy consequences of its violation is still in the process of development, broaden their perspective through vicarious participation in "The Lives [and Sorrows] of Others." The reaction papers they have written after viewing the film have confirmed just how deeply the film's portrayal of a society subject to "total surveillance" and their identification with the film's main characters have affected their understanding of the value of privacy. Since the film is set in the Deutsche Demokratische Republik (East Germany) in the late 1980's and therefore involves only quite primitive technology, we ask the students to "project" the experience into the current environment in which the modalities of surveillance are far more sophisticated, pervasive, and invisible. This, too, seems to have the effect of creating a greater consciousness of the dimensions of the privacy/surveillance conundrum.

There is one final point about the content of and approaches used for this course that we would like to make before closing this paper. During our analysis of the exam answers in response to the question "Ten years from now, what do you imagine will be the most important thing(s) that will remain with you from this course?" we noticed that several students indicated that because of the course they would always remember to practice sound software engineering practices "even though I doubt I will ever be working on life critical software or software that would be used in a national election." Upon reflection we realize that due to our use of dramatic case

studies and examples we may have obscured an important truth – the issues discussed in our course with respect to system design and software development are not just related to dramatic cases – they apply to the entire spectrum of system development. We need to make sure that this idea is clear, but how?

An approach we may use the next time we teach the course is to devote some time towards the end of the semester to discussing the ethical issues related to local projects. In any given semester within our department there are always several student development projects underway – either long term research projects or projects required for one of our courses such as software engineering or senior projects. We envision capturing descriptions of a set of these projects on video, supplied by the students undertaking the projects. We can post a collection of these descriptions on-line and have the students in the Ethical Issues course, perhaps in groups of size two or three students create a report about one or more of the projects identifying potential ethical issues related to the project and approaches that could be used to address the issue. Benefits of such an assignment would be three-fold: it would dispel the myth that such issues only arise on rare projects; it would provide a review of the course material since the wide variety of development projects typically underway would touch on many themes treated in the course; and it would provide practice on addressing and solving ethical issues on the level of a reasonably sized project – exactly the sort of projects many these students will find themselves involved with as they leave our academic hallways and begin their careers. By putting these lessons in practice early and often we believe they will become part of students' professional patterns of behavior and carried with them deep into their careers.

References

1. The Ethics Education Library, available at http://ethics.iit.edu/eelibrary/, last accessed 15 June, 2012
2. ABET Board of Directors: ABET Criteria for Evaluating Computing Programs, available at http://www.abet.org/uploadedFiles/Accreditation/Accreditation _Process/Accreditation_ Documents/Current/cac-criteria-2012-2013.pdf, last accessed 15 June, 2012
3. Computer Science Curricula 2013, ACM/IEEE-CS Joint Task Force, http://ai.stanford.edu/users/sahami/CS2013/strawman-draft/cs2013-strawman.pdf. last accessed 15 June, 2012
4. Leveson, N., and Turner, C., An Investigation of the Therac-25 Accidents, IEEE Computer, volume 26, no. 7, pp. 18-41 (1993)
5. Winograd, T., Computers, ethics and social responsibility, Computing and Human Values: Proceedings of the 1991 Conference , New Haven, 1991
6. Vaidhyanathan, S., The Googlization of Everything, University of California Press, 2011
7. Boisjoly, R. M., Ethical Decisions -- Morton Thiokol and the Space Shuttle Challenger Disaster, American Society of Mechanical Engineers Annual Meetings, 1987
8. Moor, J. H., "What Is Computer Ethics?", In T. W. Bynum (ed.), Computers and Ethics. Blackwell, pp. 266–75. 1985
9. Barlow, J. P., "Coming into the Country," Communications of the ACM, January 1991
10. Gotterbarn, D. "Computer Ethics: Responsibility Regained.". National Forum: The Phi Beta Kappa Journal, 71: 26–31. 1991

11. Weizenbaum, J. "On the Impact of the Computer on Society", Science 12: Vol. 176 no. 4035 pp. 609-614, May 1972

12. Davis, M., "Thinking like an engineer", Philosophy and Public Affairs, vol. 20, no. 2, pp. 150–167, Spring 1991

13. Tufte, E.R., Visual Explanations: Images and Quantities, Evidence and Narrative, Graphics Press. 1997

14. Nissenbaum, H, "Computing and Accountability", Communications of the ACM, January 1994, 37, 1, 73–80. 1994

15. Kerr, O.S., "Updating the Foreign Intelligence Surveillance Act", The University of Chicago Law Review, Vol. 75, No. 1 (Winter, 2008), pp. 225-243, 2008

16. Bellovin, S.M., Blaze, M.A., Diffee, W., Landau, S., Neumann, P.G., Rexford, J., "Risking Communications Security: Potential Hazards of the Protect America Act", IEEE Security and Privacy Magazine, Volume 6, Issue 1, January 2008, pages 24-33, 2008.

17. Stallman, R., "Why Should Software Be Free", http://www.gnu.org/philosophy/shouldbefree.html, last accessed 15 June, 2012

18. Raymond, E., "The Cathedral and the Bazaar", http://www.catb.org/esr/writings/homesteading/, last accessed 15 June, 2012

19. Lessig, L., Code and other laws of cyberspace. New York. Basic Books. 1999.

20. Boyle, J., The Public Domain: Enclosing the Commons of the Mind, Yale Press, 2009

21. Hardin, G., "The Tragedy of the Commons," Science, 162(1968):1243-1248, 1968

22. Carr, N., "Is Google Making Us Stupid?". The Atlantic 301 (6). July 2008

23. Wu, T., Goldsmith, J., Who Controls the Internet?, Oxford University Press, 2006

24. Singer, P.W., Wired for War: The Robotics Revolution and Conflict in the 21st Century, Penguin, 2009

25. Kohno, T., Stubblefield, A., Rubin, A.D., Wallach D.S., "Analysis of an Electronic Voting System" , IEEE Symposium on Security and Privacy 2004

26. Penha-Lopes, J.M., "Why use an open source e-voting system?", Proceedings of the 10th annual SIGCSE conference on Innovation and technology in computer science education, September 2005

27. Forster, E.M., "The Machine Stops", http://archive.ncsa.illinois.edu/prajlich/forster.html, last accessed 15 June, 2012 (1909)

28. NSPE, "Code of Ethics for Professional Engineers", http://www.nspe.org/Ethics/CodeofEthics/index.html, last accessed 15 June, 2012

29. von Donnersmarck, F.H., The Lives of Others (German: Das Leben der Anderen), Film, 2006