Professionalism in Computing: A Web-based Learning System

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Abstract

Starting from a project to develop a digital library for a Computer Science course studying social impact and computer ethics, a highly interactive Web-based learning system is in the process of development. Capable of supporting a variety of teaching/learning environments, the system is intended to support teachers whose disciplinary primary interest is other than social impact and ethics.

The Problem

In 1984 a joint committee of the Association for Computing Machinery (ACM) and the IEEE Computer Society (IEEE-CS) began work on the criteria for the accreditation of Computer Science programs in US colleges and universities. At the time of the establishment of Computer Science Accreditation Commission (CSAC), there was considerable concern throughout the computer industry regarding the emergence of computer users who saw the networking of computers as a challenge to their ingenuity and to their expertise in circumventing security systems. These persons were dubbed "hackers" by the press, using a term that had previously been applied to intelligent, innovative, but generally benign, pranksters. While the problem of securing computer systems was by no means new in the mid 1980s, the advent of the personal computer and the inexpensive modem opened up opportunities for nefarious users to extend their reach beyond their personal domain. At the same time, though again not a new phenomenon, it was understood that the reach of the computer would have extensive social impact on the society into which it was infiltrating, far beyond the extent that had been realized with main frame computers.

Against this background the commission included, as part of the requirements of the curriculum of an accredited Computer Science program, coursework in ethical and societal impact. Over the past 10 years this has manifested itself in Computer Science programs in two forms: (1) as a special course, taught variously at the

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freshman level in some institutions to a "capstone" course for seniors at other colleges and universities; or (2) as a distributed presentation, whereby topics in social impact and/or ethics are discussed in several different courses at a point where the technical material being taught is appropriate.

It had been recognized as early as the mid-1960s (Licklider[2], Fano[3], Gotlieb[4]) that the computer could and would have an impact on society, though their negative expectations were not as severe as we have experienced actually in the past 30 years. However it was institutions with sufficient faculty resources that were ready to provide ethical and social impact studies to their students. In only a few cases, before the instigation of the CSAC requirement, was there a corresponding course part of the curriculum of computer science majors. Moreover there was a stigma associated with scientists who were perceived to belittle their credentials by turning their attention to non-scientific subjects such as ethics and social impact. There is still only a tiny cadre of computer science faculty in US universities and colleges who are interested in the topic and even fewer who have the opportunity to teach it. At the same time there is opposition to permitting faculty from other disciplines to teach "Computer Ethics" or "Social Impact". Whether the presentation is in a concentrated source of study or is distributed in scenarios across a number of courses, there still exists a need for support for the discipline specific teacher. This paper describes the steps being taken and proposed to satisfy not only these two styles of presentation but also many other educational paradigms.

Teacher preparedness for managing a learning experience related to almost any subject is a function of the ready availability of support materials. The most successful teacher is frequently the one that has the best access to background resources and, in the case of ethics and social impact, this includes keeping up-to-date on contemporary issues. Textbooks can provide the core of a course, but current topics require an on-line reporter, analyst, and librarian to add new materials as they become available. One part of the problem is that as new topics arise they initially receive a great deal of attention in the press and frequently corresponding commentary in newsgroups, but there is rarely a responsible observer who will maintain a on-going summary of the status of the incident and ultimately to produce a closure statement. Even in cases where there is a definitive end to the event, such as the passage of a piece of legislation, or the resolution of a dispute through the US Supreme Court, the story of the development of the result is an important part of the understanding needed in the study of ethics and social impact. While threads in newsgroups collect the commentaries into a single line, the analysis and evaluation of arguments and situations is necessary to create a learning environment regarding the subject. This is not only a requirement for the ultimate cohesion of the library of supportive materials, but also the fluidity of the overall topics of ethical standards and social impact in computing creates an opportunity where students can use non-terminated collections of reports

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[2] Licklider, J.C.R. March 1960. "Man-Computer Symbiosis", *IRE Transactions on Human Factors in Electronics*, volume HFE-1, pages 4-11.

[3] Fano, R. M. 1967. "The Computer Utility and the Community", *1967 IEEE International Convention Record*, Part 12, pp. 30-34.

[4] Gotleib C.G. and A. Borodin. 1973. Social Issues in Computing, Academic Press, New York, 284 pp.

to develop their own analytical, evaluative, and presentation skills.

A knowledge of computer ethics and social impact is an important subject for study in most disciplines today since the computer has entered into the toolbox of most professions. The existence of a source of classroom materials and information related to computer usage will assist in spreading the word that there are standards for the use of computers and the expectations of clients who are served by computer systems.

Prior Work

Starting in 1994 the Department of Computer Science at Virginia Tech undertook a National Science Foundation project in Educational Infrastructure (CDA-9312611) to investigate the application of digital libraries to computer science education. This project, which is completing its term in 1997, commenced its work contemporaneously with the "opening" of the World Wide Web and quickly turned its attention to the use of the Web as the delivery mechanism for digital libraries. Since that time the principal investigators and associated research assistants have applied digital library and Web technology to the presentation of course materials for 75% of the courses in the curriculum of computer science majors at Virginia Tech. The work moved from the use of a passive system to a system with much greater interactivity. Initially this involved the integration of World Wide Web presentations with Internet tools, and expanded to take advantage of the CGI and form capabilities of second generation Web browsers (using PERL and C++), and later to Web Applets implemented in Javascript and Java. Among the tools developed and given limited application were an on-line testing mechanism and an on-line debate system.

Starting in Fall 1994, a part of the digital library, in support of a junior-level major's course entitled "Professionalism in Computing" was developed and used as the vehicle for a number of experiments in the use of the Web for course support (http://ei.cs.vt.edu/~cs3604). This development continued throughout the term of the NSF project, eventually resulting in a collection of over 3000 Web pages. The collection is organized into a number of directories and into two major sections corresponding to topics of general interest and those specific to Virginia Tech and this particular course. The latter "front end" section incorporates not only administrative materials such as the university required syllabus, grading policies, and course policies, but also topics that are peculiar to the Virginia Tech curriculum requirements. This includes a section on the history of computing that has taken on a life of its own (http://ei.cs.vt.edu/~history) and now gets the greatest number of hits per month of any other collection of course materials in the department[5]. Other directories in this section concentrate on writing and communications that are part of the skills practiced in this course, and a directory on "careers" prepares students for their senior year of interviewing and career decision making.

The general interest section of the digital library has been expanded by collaboration with faculty at several other institutions. From Spring 1995 a collaborative arrangement with Hal Abelson of MIT Computer Science Laboratory has allowed the two institutions to share resources, some of it in the form of links from the general interest section to pages stored at MIT

[5] A large number of hits occur on the Virtual Computer Museum at http://video.cs.vt.edu:90/history.

and the mirroring of some pages so as to ensure the archiving of the materials in one place. An agreement with Arlene H. Rinaldi of Florida Atlantic University provides a directory on "Netiquette" to both institutions. In Fall 1996 the IEEE Computer Society Press published Ethics and Computing by Kevin Bowyer of the University of South Florida, the first comprehensive textbook that matched the goals and syllabus of the Web materials developed within the EI project. It was decided to make some minor modifications to the general interest directories and to collaborate with Prof. Bowyer in using the Web as support for the textbook.

From the beginning it was expected that these materials would be used by different faculty at Virginia Tech who would put their own "twist" on the course. No matter how good the textbook, how extensive the resources, how detailed the notes, every faculty member has their own way of presenting materials, adding their own imprimatur and incorporating their own experiences. It was important therefore to modularize the digital library so as to allow each teacher to organize the materials according to their own desires. However, it was realized as the library developed that in moving from a lecture presentation mode of learning to a self-paced, Web-based learning environment, the peculiar influence of the librarian/Webmaster diminishes and the needs of the learner can be fulfilled better with a less structured strategy. This approach also has the advantage that, by eliminating a fixed structure, the contents can be readily updated as new problems arise, new laws are promulgated, precedents are established in court cases, or international diversity is recognized. On the other hand each module includes a sample class outline, a set of class notes, a bibliography, and a collection of in-class projects.

The development of a digital library to support teaching and learning in computer ethics and the social impact of a computer through the earlier NSF grant has now reached the point where it is has begun to move from an primarily passive system to a much more interactive arrangement. Initially interaction was provided through the development of an on-line debate system (http://ei.cs.vt.edu:8000/). Prior to the development of Web-based resources, this course had used an "Oxford Union" style debating system to discuss ethical scenarios and current issues. With restricted class time, this provided the opportunity for only a limited number of students to participate, and much of the discussion relied on spur of the moment reactions in order to contribute to the argument. A survey of student participation revealed that in the main the debates were dominated by extroverted white males, while more thoughtful women and students whose first language was not English were at a considerable disadvantage. By putting the debate on-line and allowing several days for participation, it was immediately apparent that there was a wider diversity of opinion and more reasoned contributions. The latter benefit was partially instigated by the requirement that the price of participation was the inclusion in each contribution of either a (preferably Web-based) reference or a conjunction of the argument with an ethical principle. Further "me-too" statements were outlawed and negative contentions were required to be accompanied by a rationale. Initially the debate system was organized as four tree structured threads, the initial node of each branch being one of four primary position statements developed by the debate management team, succeeded by the point and counterpoint statements from the class participants. As other courses began to use the system as a

collaborative development methodology, it was modified to permit a number of different arrangements basically varying from the strict discipline of the debates to the "free-for-all" of a chat room.

In the Spring semesters of 1995 and 1996 the technique of developing individualized "front ends" was used by different faculty within the Virginia Tech Department of Computer Science to organize their classes, and in Fall 1996 the course materials availability was extended to two other institutions who created front ends in their local server with links to the directories in the general interest section stored at Virginia Tech. Norfolk State University (Virginia), a partner in the NSF project, managed a seminar course with 20 participants which used the general interest directories (http://199.111.112.137/courses/couhpage.html), and Heritage College (Washington) involved 15 students in a self-paced course (http://www.heritage.edu/CPSC/480/sylf96.htm). Both institutions reported a favorable response from their students. At Heritage College the entire computer science program is populated by a single full-time faculty member and three adjuncts who simply did not have the time or resources to offer a course in computer ethics and social impact. Using the materials as a Web-based learning medium, the course provided the first exposure to the topic for students in an environment where the resources are not sufficient to support a faculty member with the necessary expertise.

Among the goals for the inclusion of two other institutions in the use of the materials was twofold: (1) to evaluate the ability of other faculty and students to assimilate the course library, and (2) to expand the debate population. On the latter point, it is recognized that the student population at Virginia Tech is primarily white, conservative; Norfolk State University is traditionally a black institution in Tidewater Virginia serving an urban community of students with a very different background from those at Virginia Tech; Heritage College is a unique liberal arts college located where no other four-year college exists. Fifty percent of the college's undergraduate students are either Native American or Hispanic Americans. Eighty-five percent are the first persons in their families to attend college and sixty percent live below the poverty level. Many Heritage students are farm workers and/or single mothers; women make up 70 percent of the undergraduate student body.

Each institution used the course library in a different manner. While Virginia Tech was still using the one-day-a-week lecture format (the other two days being devoted to student presentations and the careers seminar), Norfolk State and Heritage used a seminar format in which students studied topics using the Web-based materials (in an order of their own choosing) and then met once a week with a faculty member[6] to discuss their findings. An attempt was made to involve the three groups of (roughly 100) students in joint debates, with the hope that these three disparate populations would come down on different sides of certain issues. Three debate topics were chosen for these joint debates dealing with current issues in computing -- a case of the appropriateness of minority representation on the Board of Directors of a major computer corporation (based on actual correspondence between the company's President and a stockholder, with permission of both parties), cryptography and the clipper chip,

[6] It should be noted that at both institutions other faculty participated occasionally for the pleasure of it!

and a charge of plagiarism against an unnamed student who copied the format and background of another student in preparing a home page. While the debates were well subscribed, the differences in student backgrounds did not emerge as vividly as expected. This may be partially the result of a more restricted access to terminals at Norfolk State and Heritage than is common at Virginia Tech. It is hoped that through this project, this experiment can be repeated with improved access facilities.

In evaluating their involvement Richard Barnhart of Heritage College reported:

> Evan Anderson and I finally got together over dinner last night and did a "post-mortem" on the course. All in all it was a smashing success.
>
> With our few students, we will probably put the course on an alternate-year schedule, which means that we would do it again in the fall of 1998. We would like to make it a regular part of the curriculum.
>
> It was interesting over the course of a couple of weeks to see the class's attitudes changing over the plagiarism/copyright/"look and feel" question. Their initial reaction was "get a life". They came to understand that there are many such issues that they will face, especially since most of them will be "the" computer person for some company or department, and that people will have questions and issues come up constantly. These students very frequently will have network privileges into all parts of the corporation; many of them had never thought of this in the context of ethics.
>
> We might like to do a similar kind of thing in 1998, but include several small colleges in the Northwest, such as Whitworth and George Fox. I'm thinking that this could get out of hand if it were all done through Virginia Tech, considering the logistics. Perhaps we could use your model and do something more "local"; or maybe it's feasible for Tech to handle it. As you probably realize, it's a long ways between places out here, even in Washington which is the smallest of the Western states. It's 4 1/2 hours to Whitworth (in Spokane), 3 1/2 hours to George Fox (in Oregon), 3 1/2 hours to any Seattle/Tacoma schools, etc. There are dozens of small colleges that could benefit from an interchange of ideas.

Unsolicited responses were received from other institutions who had used the materials but had not “registered” with us as participants in the experiment. Typical of these (and most interesting) is the comment from the United Arab Emirates (earle@emirates.net.ae):

> Just a quick note to say that I really have enjoyed visiting your site, and in particular reading the student responses to your ethical dilemmas.
>
> I am trying to build a similar (if lower level) course on computer ethics for some Higher Diploma Information Administration students in Abu Dhabi, United Arab Emirates and think that your idea of creating an on-line discussion group is an excellent way of making the students come to grips with ethical dilemmas in a way which extends far beyond a listing of the 10 commandments...

> This should be interesting as my students are all women, have very strict Muslim social codes and have, in many cases, led very sheltered lives.

During the Spring semester 1997 the library is being used by a University Honors Colloquium on "Internet Issues" being organized by a faculty member in the Department of Chemistry. It is hoped that these students will participate in the on-line debates.

The content modules (or directories) related to the social impact and ethics course currently cover the following topics:

- Censorship (and Freedom of Speech)
- Community Standards
- Computer Crime (and Computer Law)
- Computer Impact
- Ethical Foundations
- Hacking
- History of Computing
- Intellectual Property
- Liabilities
- Netiquette
- Personal Relationships
- Privacy (and encryption)
- Responsibilities
- Viruses, Trojan Horses, Bombs

Each module is currently organized to include five major files composing the nub of a classroom experience:

- The introduction, giving the goals and objectives of the class, links and references to basic readings, and a link to a set of class notes.
- The class notes in a form that can be used for overheads for a lecture[7] or as a set of notes for student self-paced learning.
- A bibliography relevant to the topic especially emphasizing links to on-line resources so as to provide additional reading materials in support of the class. As far as possible, the majority of the on-line references in this file are contained in the same directory as the bibliography, though copyright restrictions have limited the accessibility of some material. Links are also included to items stored in the digital libraries developed through the ENVISION[8] and SUCCEED[9] projects that contain many articles originating in the journals and magazines of professional organizations.
- A collection of in-class projects which require groups of participants to review the pertinent materials and then prepare a class presentation on some particular aspect of the topic.
- A collection of synthetic and real-life scenarios for use in in-class

[7] The notes exist in several different formats; some are in the form of HTML pages requiring no further application than the standard browser, others are in PDF and thus requiring the auxiliary use of an Acrobat reader. This was used in the EI project to evaluate the efficacy of each methodology. The former has the advantage of not requiring the second application, but is limited in formating (pretty-printing) by HTML capabilities. However it is easy to modify the notes and is amenable to on-line editing through special agents. The PDF style allows the conversion of materials gathered from other sources to be presented is a very attractive format. However the ability to modify the materials is much more complicated.

[8] Project Envision Final Report, NSF Grant IRI-9116991, http://ei.cs.vt.edu/papers/ENVreport/final.html, 15 October 1995.

[9] Project SUCCEED, http://succeed.engr.vt.edu/index.html, 28 January 1996.

discussions or for use in the debate system.

A special directory that is a part of this library is a collection of Codes of Practice, Ethics, or Conduct that is maintained on behalf of the International Federation for Information Processing (IFIP) Technical Committee on the Social Impact of the Computer (TC-9). This collection of codes was originally developed as a part of an international effort to develop a common code of ethics for national computer societies. While that effort did not result in a common code, the collection of codes forms a valuable source of materials for the comparative study of national attitudes towards the use of computers. The collection has been extended to include the codes of many other non-computer related professional organizations, and several policies of computer usage from US universities. Also included is "Toronto Resolution", a guideline for the development of codes of ethics developed in 1992[10] by an interdisciplinary meeting of scientists and professionals. This page is credited with assisting the Philippine Computer Society to develop a code for their membership. The collection can also be used by students to study existing codes and their application to ethical situations. A recent addition was the "Hacker's Code of Ethics" developed by Steven Levy.[11]

10 http://ei.cs.vt.edu/~cs3604/lib/WorldCodes/Toronto.Recommendation.html

11 Levy, Steven. 1984. Hackers: Heroes of the Computer Revolution, Doubleday Press, 1984.

The Next Step

Building on the digital library, the next step will extend the learning environment to take advantage of the now emerging interactive facilities of the World Wide Web and their supporting browsers to create a Web-based learning facility. The digital library is already modularized to give emphasis to specific topics, and this can be further subdivided in order to focus a learner's attention to threads of interest or to localize current issues during their development phase. The proposed system will incorporate self-paced learning modules, on-line self-evaluation, on-line testing, discussion groups, debate systems, mechanisms for on-line updating and extension of modules, mechanisms to build study threads through the libraries of materials, topical issues forums, and survey mechanisms.

Web-based learning is a growing phenomenon that has yet to reach its full capability. Much has been made of the Web simply as a passive searchable resource, and our experience already records that many learning opportunities have been satisfied through this mechanism, but data "mining" is truly only a precursor of data analysis and refinement. Substantive learning can only be achieved through the management of data acquisition, and the collaborative development and reinforcement of concepts. The general tenets of Computer Aided Instruction (CAI) can now be implemented in a Web-based learning environment built and maintained on the basis of a digital library. The Hypertext domain is particularly suitable for the maintenance of changing data, particularly in a subject area which is evolving as rapidly as computing.

As a teaching/learning community, we are currently in a period where the manner of teaching and learning is

changing, and the emphasis is moving from lecture based teaching to self-paced, self-evaluated, individualized learning environments tailored to the needs of the individual student. Data collections and digital libraries are merely the resources upon which self-paced learning modules can be built. However, the concept of a library of materials to which individual faculty can link to formulate learning programs through the use of individualized "front ends" begins to provide this capability. The library will contain sample lesson plans or templates that may be used to construct learning experiences. The most effective means of providing this capability must be through on-line editing capabilities that will allow teachers to create Web-pages without the necessity of learning such mechanisms as HTML or CGI. This capability must also extend to the creation of mechanisms that will allow learners to evaluate their attainments through on-line tests. The results of tests may be used to control the flow of a lesson plan, or to enforce new learning directives. Tests may also be used to suggest additional assignments that may be evaluated off-line. We have already developed a prototype testing facility named "QUIZIT" has been successfully used in a single Web environment.[12] Currently QUIZIT is compiled from an extension of HTML using forms, and requires off-line editing and uploading of the pages to the appropriate server. QUIZIT is protected by a security system involving the use of identification names and passwords that is similarly constructed through an off-line process. We plan to re-implement the prototype moving it to a Web-based system allowing authorized users (teachers, learning managers) to create and control test systems. Record keeping is being incorporated to allow teachers to monitor student progress and, if necessary, to assign grades.

Collaborative education has a place in modern learning environments giving students the opportunity to comprehend ideas with their peers and to build on learning experiences of others by short circuiting their educational activities and being able to jump directly to conclusions without the necessity of sifting through libraries of data. The current debate system for the course needs to be extended a permit a wider variety of discussion styles. Moreover the debate mechanisms (together with the supportive security systems) will be moved from a machine language system that is primarily maintained through off-line modifications to an on-line system. Besides the simple chat-room style of contributing to discussions and debates, the collaborative development system also must be capable of allowing participants to edit and modify documents, merged with a version mechanism to allow the consensus of the participants to select a conclusive synopsis of their explorations. A prototype mechanism to annotate modifiable Web pages has been implemented to allow debate participants to create Hypertext links from a previous user's contributions to new arguments.

An important component of the social impact and ethics learning environment can be a statistical survey generation and polling system. Within the topic of social impact and ethics, surveys may be used to examine public and changing attitudes toward certain issues. For example, one class undertook to examine student attitudes towards the 100 year-old University honor system. To the astonishment of the class it was revealed that over 50% of all of their colleagues had cheated on examinations or tests, and the majority agreed that they would not

[12] http://video.cs.vt.edu:90/~telfer/

turn in colleagues whom they discovered to be cheating. These results were later confirmed in a national study by the Josephson Institute[13]. The mechanics of selecting participants must allow for both the surveying of class colleagues and for broader samples. Class participants are already tainted by being exposed to the more positive aspects of computer ethics and thus any survey among this select group would not be typical. The recent experiences of the students at Smoky Hill School in Aurora, Colorado, who implemented a survey system as part of their CyberDome Web[14] pages, were excellent. While they chose to restrict their surveys to members of the school system, the responses were very revealing of attitudes and opinions of the peers.

At this time the organization of the ancillary articles in the directories is essentially planar, the only structure coming from the links in the basic readings list and the bibliography. Our experience in building a Virtual Computer Museum (http://video.cs.vt.edu:90/~museum) shows that it is possible to create on-line threads or routes through the material through the use of keywords and codes that provide attribute information regarding the content of the articles. These mechanisms will be installed in the next stage through the use of Applets that may interlink pages (and segments thereof), and providing each page with the ability to have their characteristics modified during their lifetime. This mechanism also can be used to rank articles in the order of their frequency of usage or by other criteria that can be determined by the user —by the learner or the learning manager. This information will be important in maintaining the course materials and in assessing the effectiveness of the thread systems.

A major part of the assembled materials in each directory is a collection of scenarios or cases that pertain to the topic. These comprise two forms of case: an actual case history or a synthetic scenario. An actual scenario in the collection is the article on the Therac 25 incident which has been used as a case study for several years. Other cases include (1) the story of PGP (Pretty Good Protection) developed by Phil Zimmerman[15] and the subsequent problems with the classification of the encryption system as an "armament" and the consequential limitation of its exportation through the Internet, (2) the case of a student at the University of Michigan who published a poem in a newsgroup that visualized violent acts against a named student in one of his classes, and (3) the case of Bob Morris who inserted a virus into the Internet and caused the crashing of a large number of UNIX servers. Such cases are particularly important since they show learners that social impact and ethics is not a subject of simply academic interest but rather is part of the daily life of computing. Conversely the synthetic cases are designed to provide "food-for-thought" in discussion groups and are generally designed to present two diverse reasonable viewpoints. The inclusion of such case reports in the library is an important element of the collection project. From these reports will come case studies developed by the participants, and retained in the library for other students to review and build upon. In fact, the retention of student contributions in the library will be an integral part of the continuing work. This will help in not only expanding the content but will also create a model for others to

[13] Josephson Institute of Ethics, Marina del Rey, Calif.

[14] http://ww.smoky.org/utcd/

[15] http://www.pgp.com/

emulate in their own research, study and writing.[16]

Through the mechanisms for teachers and learners to develop their own "front ends" to the library of materials, and means to navigate the collected items in different manners, several styles of presentation are possible:

- Self-paced, "Keller" plan learning
- In-class group projects
- Seminars
- Conventional lecture plans
- Distributed presentations (in several courses and several locations)
- Distance learning
- Collaborative learning

Several other institutions are planning to use the present digital library in different manners, to test the adaptability of the system. To ensure that front ends are developed correctly, it will be necessary to provide Web page authoring facilities that will ensure that all the appropriate pages in the administration section are modified.

In the past two years, NSF has supported an activity to better define and characterize the topic of "computer ethics" through the ImpactCS project led by Dianne Martin. Our next step is intended to be supplemental to that work and as far as possible to implement, in a Web-based environment, the recommendations of that project. For example, the ImpactCS project suggests the use of "laboratories" in which students examine issues and report on their findings:

ES1: Responsibility of the Computer Professional
Suggested laboratories (4 hours):

1. Divide students into small groups and assign an important technology, such as the clock, the internal combustion engine, electricity, or television to each group and have them discuss how the invention and widespread adoption of this technology changed society. Who were the winners and who were the losers when the new technology was adopted?

2. Have individual students read or view a work of science fiction and then report back to their small groups about the author's view of technology. Is technology viewed as beneficial or evil? Who is in control in the work - people or technology?

3. Have students identify where their personal values fit into classical ethical models and professional codes of ethics presented. Then have them discuss a case study in small groups using their own personal values as the basis for decision-making.

4. Have students do a written case study analysis using a professional code of ethics and then discuss their analysis with other students in small groups.[17]

This style of collaborative activity (whether called a laboratory, a recitation session, or a seminar meeting) can readily be incorporated

[16] As an ongoing project, student essays and reports on aspects of computer history have been added to the supporting notes of the PBS video series "The Machine That Changed The World" to provide background information for "further reading" by the viewers.

[17] http://www.seas.gwu.edu/seas/impactcs/index.html

into the structure of the Web-based learning environment used here. Individual faculty members could choose to conduct these sessions off-line in the classroom, or may desire to open the discussion to a student body that is larger than those in a single room. In general, the recommendations of the ImpactCS project can be implemented through the WWW and through this project.

Among the new topics to be added to the digital library (and consequently the interactive learning environment) are:

- Fraud and Dishonesty in Business
- Conflicts of Interest
- Discrimination and Harassment in the Workplace
- Personal Information
- Whistle Blowing
- Safety-critical Systems

Outcomes

As a result of this work the computer science curriculum across the US, and possibly across many other countries, can be refined and improved by the availability of a central repository of learning materials that will support the efforts of faculty in computer science who are not primarily trained in ethics and social impact. This will lead to the greater infusion of the topics into the curriculum of computer science programs. Graduates of computer science programs will have a deeper understanding of their responsibilities and liabilities, and during their academic career will be more aware of the standards that should guide their behavior. It has been our experience, reflected in the assessment from Heritage College, that many students have a "oh yeah!" encounter during this class. At Virginia Tech, where a large proportion of students are involved in cooperative education, it is not uncommon for students to reflect on their industrial activities and realize that they have been put into non-ethical situations because of their lack of understanding of proper procedures and codes of conduct.

The computer science curriculum, apart from the single requirement for exposure to social impact and ethics, concentrates on technical learning based on formal logic, mathematical theory and statistics. Decision making in the technological arena is based on well established data, and so for the Computer Science major analytical reasoning in a more subjective discipline occurs only in this one course. As a result of this learning experience, provided that there is more to the learning than just data collection, Computer Science majors can expand their abilities in analytical reasoning and evaluation of arguments. The on-line debate system formalizes argumentation and reasoning to a greater degree and is more effective as a learning tool than the "seat-of-the-pants" and "instant-reaction" class discussion. Especially for Computer Science and Computer Engineering majors who are more fluent on the Internet than they are face-to-face, this provides an outlet that they would not have otherwise. For students who are participating in a self-paced experience, their involvement in on-line debates must be an important part of their learning. For this reason, the administration of the site must include on-going debates or discussion groups to accommodate individual learners who are not necessarily a part of a larger class. Similarly debates among students hosted in several different institutions, such as the community of colleges suggested by Heritage College, can be organized through the on-line debate system. No matter how learned the teacher of a course or the leader of a seminar, the involvement of students in a debate that includes students from

other institutions will assist in widening their viewpoint.

Some institutions choose to distribute the study of social impact and ethics across several courses, relating the presentations to the topics within technical courses. A discussion of Netiquette, for example, is perhaps best introduced at the time that students are first introduced to InterNet communication through e-mail, newsgroups, and LISTSERVs. Security, hacking and viruses are pertinent to the study of operating systems, while intellectual property is appropriate to programming when students first produce objects which are their personal property. There is no reason why this approach to studying the social impact and ethics cannot benefit from the centralized digital library. For example, a course entitled "The Introduction to Computer Science", commonly called CS1 after the designation of the course in the ACM/IEEE-Computer Society curriculum, in a Web-based environment may include links to certain elements of social impact and ethics Web-site without passing through the formal front ends expected of comprehensive courses. We already use this technique in building Web-sites for courses which have other courses as prerequisites. Reminding students of the knowledge presumed in the second course by linking back to the prerequisite course is an excellent means of forming an educational continuum unbounded by semesters and time.

For some years we have pushed for the inclusion of ethical considerations and exposure in pre-college institutions. We have likened computer education to sex education and driver education; each introduce students to techniques and equipment; in sex education and driver education the teachers accept that there is more to learning the subject that simply learning the theory and mechanics; both require the discussion of moral and ethical issues. Computer education is no different. Like the faculty of college computer science departments, teachers in public schools are equally unprepared to teach the social and ethical dimensions of computing. In the school system, the case study approach is most effective. The availability of scenarios and cases on the Web-site especially when supported by analyses and commentaries will assist in getting the message about the appropriate uses of computers to students during their early years of using computers at the time when their concepts about computers are being formed.

The tools necessary to effectively support this project will also have effective applications in other areas, such as chemistry, biology, or engineering. On the one side this model will have application in the development of similar sites relating to the social impact and ethics in other disciplines. The tools will have application in the development of Web-sites for topics other than social impact and ethics.

Beyond these auxiliary outcomes, the primary outcome of this work will be the wider augmentation of computer science curriculum by the inclusion of studies of social impact and ethics.

Dissemination

In the summer of 1997 the current Educational Infrastructure grant will close its term with the organization of a workshop for faculty interested in Web-based learning techniques in which the use of the social impact and ethics system will be presented.

From one point of view it is possible to argue that the use of the Web for the presentation of course materials on social impact and ethics is an automatic

means of dissemination. Those interested will find their way to the site. However, the mere existence of a site on the Web does not means that it is necessarily used appropriately. For the most part the World Wide Web is a passive medium whereas what is needed here is a pro-active approach to dissemination. Even within a single course it is necessary to use other means of communications than just the Web. For example, we started with the concept that changes and modifications to the Web pages could be announced most easily by the introduction of a special Announcements page. While this is useful as a tracking device for those who are not "registered" to use the materials, the fundamental passive nature of the Web must be supplemented by the use of more pro-active e-mail, LISTSERV, or newsgroup communications.

Long-time support

Following the completion of this current work, it is hoped that Virginia Tech and other participating institutions should be ready to provide a Webmaster for the Web-pages and the maintenance of the supporting system. The faculty involved in teaching and managing courses based on the collection of materials and tools should be expected to continue to contribute to the collection and to continue to develop learning modules. It is intended that the course materials will be available at several mirror sites and thus will provide a distributed long-lasting archive.

Evaluation

The inclusion of self-testing pages in each of the learning modules, supplemented by a scoring data base that will be necessary in any case to provide teachers with reports on the progress of their students, will provide an excellent means to evaluate student reactions to the materials. It is proposed that even those students who are involved in using the materials in lecture or seminar mode would be expected to self-test to provide a comparison with other students in the self-paced mode. This will not necessarily provide any comparison with student achievements prior to the use of the Web-based but it will assist in assessing the efficacy of the learning system. A student evaluation survey will be associated with each usage similar to that which is commonly used in Virginia Tech classes. This will provide a comparison of the student reactions to the course compared to the in-class surveys that have been executed over the past three years.

Besides collecting data on students who are formally registered to use the course materials (and who thus will not have access to the self-tests), data will be collected on the page hits and sources from other users. By including a "visitors book" it is hoped that we can also collect information on the rationale for other accesses. This will also be an opportunity to encourage faculty from other institutions to participate in the course.

With the restriction that participants in the debates include references to the source and rationale for their comments, it will be possible to examine the debate responses to measure the impact of the materials on the participant's understanding and comprehension of the topics. This will require some more detailed analysis than will be necessary with other more quantitative assessment procedures, but should be much more meaningful.

Conclusions

Web-based learning systems have the capability of being more than simply a passive information system through which students browse randomly to locate useful data. The social impact and ethics courseware that was developed at Virginia Tech as a digital library is now moving towards an interactive system that can be used in a variety of teaching/learning environments to the benefit of both teacher and student. As a topic that is still emerging as an object of study in universities and colleges, replete with developing legal precedents and new instances of challenge from a highly innovative sub-culture of hackers, social impact of computer ethics cannot be permanently encapsulated in a paper medium.

This paper is a progress report on the road from an almost obsolete technology of 1993 to the learning environment of the 21st century. What we accomplish here will be a model for other university courses, and eventually for classes at other levels. The study of the social impact of the computer and computer ethics should not be limited to post-secondary computer education, but should be available to all users of computers. Through this system perhaps we can find ways to incorporate elements of computer ethics into many courses.

Appendix I

Synopsis of the ImpactCS Project
(from www.seas.gwu.edu/seas/impactcs/index.html, 97/01/15, edited to remove references to images)

Computer Science has advanced rapidly in the last several decades, and this advance has necessitated the continual revision of the curriculum in an evolving discipline. Not only have new areas of interest been added, but new approaches have influenced the ways we think about established areas in computer science. One of the fundamental changes in computer science in the last decade is the realization that the context in which technology is used must be taken into account in its design, partly because of the ethical implications of its use, and partly because understanding the context of use helps inform and improve the design. This recognition is included as one of the foundational principles in Curricula 1991, and has been a part of curriculum standards for over a decade. Thus, as a part of the natural evolution of a maturing discipline, the social and ethical context of the discipline has been included in its basic undergraduate curriculum.

As part of our work, we present a conceptual framework that allows the instructor to see the social and ethical context within which any particular issue can be viewed. Because there are several disciplines that contribute to an understanding of social and ethical context of computing, the context we construct here is multidimensional in nature. Most of the standard topics that instructors already associate with the area will be found here. But other topics, and the intersection of many topics are also suggested by this framework. We expect it will provide the sort of comprehensive, conceptual overview that the field has been lacking until now. But since these issues change with time, we also expect this framework will need to be revised periodically to reflect those changes.

In Computing Curricula 1991, the basis for defining the curriculum is stated as the 'platform of knowledge that is considered essential for all students who concentrate in the discipline.' In this report we extend the basic platform of knowledge necessary in computer science to include a tenth subject area that will cover the social and ethical impact of computing in a comprehensive and meaningful way. Our rational for doing this now is that, because of the work of Project ImpactCS, we are able to articulate the essential core of knowledge in this new area with the same rigor and formalism that was the basis for defining the other nine subject areas using knowledge units.

A knowledge unit defines a coherent collection of subject matter that is so fundamental to the designated subject area that it should occur in every undergraduate curriculum. Frequently the subject matter of a particular knowledge unit is related to other knowledge units in the common requirements and can be introduced within any of several alternative course structures. This is often the case with the knowledge units that we will describe in this new subject area designated Ethical and Social Impact of Computing (ES). The conceptual framework, principles and skills explicated in The Consequences of Computing, the first report from the ImpactCS Project, are used as the basis of the knowledge space of this new subject area. The five fundamental knowledge units of Ethical and Social Impact of Computing are:

* ES1: Responsibility of the Computer Professional
* ES2: Basic Elements of Ethical Analysis

* ES3: Basic Skills of Ethical Analysis
* ES4: Basic Elements of Social Analysis
* ES5: Basic Skills of Social Analysis

Appendix II

Nov. 1996 NSF EI PI Meeting Report
Edward A. Fox
October, 1996

1. Institution: Virginia Tech

2. Title of Project: Interactive Learning with a Digital Library in Computer Science

3. List of PIs: N. Dwight Barnette, Edward A. Fox (director), H. Rex Hartson, JAN Lee, Clifford Shaffer

4. Overview of Goals and Objectives: Key concepts of our project are to improve CS education by increasing interactivity and use of a digital library. The main objectives/accomplishments were to: expand the content and software (especially interfaces) initially developed with NSF support of our "Envision" digital library project, "A User-Centered Database from the Computer Science Literature"; develop/apply algorithm visualization tools that are easy for instructors to use in supplementing courses, and feasible for students to work with as an aid to program development and debugging; incorporate use of specialized digital library systems like Netlib into related courses; add new courses related to human-computer interaction, multimedia, and a freshman level introduction to Networked Information; significantly change courses like "Computer Professionalism," to make use of interactivity (e.g., asynchronous on-line debates) and digital library support (e.g., adding to a large History collection); and apply the key concepts to improve other courses.

5. Current Status and Accomplishments: In 1991 Virginia Tech began working with ACM through support from NSF on a "User-Centered Database from the Computer Science Literature". In 1993, Virginia Tech expanded its work on digital libraries to launch the NSF EI project, partnering with Norfolk State University, which has developed extensive sets of laboratory manuals. Over 25 courses are available through WWW, leading to over 1.8M accesses since 1995. There are several gigabytes of ACM publications available. A server to handle authentication and other tasks has been installed at ACM Headquarters in NYC. Ongoing collaboration between ACM and Virginia Tech is being expanded to include IBM Research and their digital library systems. Several courses have all the on-line materials required for self-study available, and new programs are under development for distance learning and continuing education. In the new multimedia course, there was a dramatic increase in bandwidth required for the 1996 offerings as compared to the 1995 ones, because of more images, digital audio, and digital video. Due to the development by Prof. Lee (editor of *Annals of the History of Computing*) of one of the largest repositories on computer history, with a unique image collection of the founders and early systems in our field, there is extensive additional traffic from throughout the nation. In 1996, with the help of NSF-funded digital video capture and editing facilities, audio annotations, digital video movies, and animations to show interactive applications have been added. One of the courses developed under this effort, and extended through support from SUCCEED, is CS1604, an introduction to networked information. A self-study version of this course will be finalized later in 1996, and is expected to be widely used

throughout the Southeast and beyond by those interested in a freshman or beginner-level orientation to Internet, digital libraries, collaboration technologies, etc. This version has numerous audio and movie files to help learners, an automated real-time feedback facility (using our SGML-based QUIZIT tool), and a variety of illustrations and demonstrations. In one old and two new courses, we have adapted Keller's Personalized System of Instruction to our networked environment. Students proceed at their own pace, study on their own, get help through asynchronous communication with peers and instructors, and in general have much greater flexibility in learning. Many students prefer this type of course, and in the case of CS1604 (Introduction the Internet) we simply could not accommodate the demand any other way, in this time of scarce resources. However, students have requested that we add interim deadlines, since they tend to procrastinate and require help with time management - this seems to solve the major problem faced earlier.

6. Plans for Remainder of Project: As our project winds down, we are getting new hardware to support the increased server load, disseminating results further, and seeking local and other support to extend our efforts further.