Computers and Society in CS0: An Interactive Approach

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Abstract - **One of the challenges in developing introductory computer science courses for non-majors is attracting and engaging a diverse population of students. Incorporating the social, legal, and ethical issues in computer science into the course material is one effective way to introduce students to the concept of computing as a science and to demonstrate the relevance of the discipline to their everyday lives. In this paper, we propose a series of classroom and web-based activities in which the students take an active role in researching and learning the societal impact of the current technical subject studied in class.**

Index Terms - Computer science education, CS0, in-class debates, social issues

INTRODUCTION

One of the challenges in developing introductory computer science courses for non-majors is attracting and engaging a diverse population of students. Incorporating the social, legal, and ethical issues in computer science into the course material is one effective way to introduce students to the concept of computing as a science and to demonstrate the relevance of the discipline to their everyday lives. In this paper, we propose a series of classroom and web-based activities in which the students take an active role in researching and learning the societal impact of the current technical subject studied in class.

Once presented with a particular development in computing, students will first research its impact and consequences and the social, legal, and ethical questions raised as a result. The Internet should be used as a primary research tool as well as a forum for discussion in the next activity. Following their research, students will select a set of questions and outline either a supporting or dissenting argument for each. They will make this information publicly available to the class via the course discussion forum, and as the next step they will read the arguments of other students and prepare and publish counterarguments. As the final step the students will have a formal in-class debate, where students perform one of three roles: affirmative, opposition, or judge. These activities culminate in a final project.

The remainder of this paper is organized as follows. We begin with the motivation for our work. We then survey related approaches to the teaching of computer ethics, the use of in-class debates, and the design of introductory computer science courses for non-majors in RELATED WORK. DEBATE TOPICS provides a selection of suitable topics for debate. In METHODOLOGY we propose a series of classroom and web-based activities focused on a single debatable topic drawn from the technical content of the course in computing that emphasize research skills, written composition and oral presentation and culminate in a final project. A preliminary study of our strategy was implemented in Summer 2003 and a full implementation followed in Spring 2004. The results are summarized in IMPLEMENTATION. We conclude with a discussion of work-in-progress and directions for future research.

MOTIVATION

In introductory computer science courses one should place particular effort on the innovative and creative teaching methods, especially for non-majors or first-year students. Students who are new to the study of computing as a science often find the combination of theoretical and technical concepts difficult and often dull. The common misconception that computer science is simply the study of computers, programming, and software applications leads many students to believe they are neither interested in nor will they benefit from an introductory course in the area. In reality, computer scientists develop theory and applications that have an immediate, direct, positive impact on people and society; in particular, on the students themselves. In parallel, the social, legal, and ethical implications for the rapidly emerging technology that computer scientists produce are not necessarily immediate, direct, or positive, yet still affect people and society. The ramifications of recent advances in science and technology is as important and far-reaching as the technology itself, and non-majors, who often take only a single introductory course, may never be exposed to the real issues in computer science.

The discussion of ethical and social issues in computing should follow naturally from the technical content of the course and relate directly to the course topics [1], [2]. Such discussion will illustrate to students the relation between the technical subjects taught class and their effect on society, the specific impact computing has on their everyday lives, and that the knowledge they gain from the class will be relevant beyond the completion of the course.

In Fall 2000, the Trinity College of Arts and Sciences at Duke University adopted a new liberal arts curriculum, *Curriculum 2000*, so titled to represent “a new beginning

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intended to be well adapted to the turn of the century and the coming age with its opportunities and challenges" [3]. Principles of Computer Science (ACM CS0) is designated as a course offering exposure to the *Science, Technology, and Society (STS) Focused Inquiry*, a requirement feature intended to engage students in themes that may be of critical importance in the future [4]. From the Trinity College requirements:

> Advances in science and technology have profoundly influenced society in the modern era. They have changed our world, both its philosophical foundations, as in the Copernican or Darwinian revolutions, and in its practical everyday experience, as in the rise of the automobile and television. STS exposes you to concepts that you need in order to confront scientific and technological issues. Courses coded STS not only explore how science and technology have affected societal development but how the needs of society have influenced scientific and technological development [4].

The objective of STS coded courses is for students to "understand contemporary issues relating to the development and application of a particular area of science and technology. Exposures should address current and future issues by critically assessing the aesthetic, ethical, sociological, and political, in addition to scientific, factors that bear on the issue" [3].

Related work

Interactive approaches toward teaching ethics in computing and its societal impact have been applied within the spectrum of computer science and engineering curricula. A summary of successful and unsuccessful pedagogical strategies based on the collective experience of educators in computer science and computer ethics is found in [5]. Among the methodologies cited as successful are interactive class discussion, critical thinking and writing assignments, use of an online discussion forum, and classroom presentations. Strategies for using technology in the teaching of ethics, in particular the Internet as a research tool and a discussion medium and using the web as a publication channel for the final course project, are discussed in [6]. The scenario analysis worksheets presented in [7] help students to develop analysis abilities with respect to ethical issue scenarios by following a logical progression of actions: finding the facts, applying professional guidelines and ethical theory towards a defensible ethical decision, and identification of actions and policy changes required to resolve the situation. The use of in-class debates as a teaching tool is considered in the context of engineering in [8] and e-commerce in [9]. At Duke University, there has been an ongoing effort to teach computer science to a broader audience through the Great Ideas in Computer Science project [10], based on the proposal that it is possible to have a treatment of a broad selection of topics while maintaining a surprising level of depth and rigor [11]. Supplementing programming laboratories with "hands-on labs" where students work in groups to physically implement algorithms was evaluated in the context of Duke University's introductory computer science course for non-majors in [12].

Debate topics

In virtually all technical areas of computer science there are social, legal, and ethical questions one can ask. What makes a good debate topic? The following characterizations are provided in [8]:

- Numerous clear and compelling arguments available for both sides to present.
- Sufficient information is available through research to support both opposing viewpoints.
- The selection of a debate topic depends upon the timing of the actual debate, i.e. the technical knowledge required for a thorough understanding of the debate topic should correlate to the breadth and depth of material presented thus far in class.

For introductory computer science courses, we propose that a good debate topic also has the following characteristic:

- The topic should be of interest to the students and demonstrate the relevance of the course material to their everyday lives.

In Table I we give examples of debate topics that satisfy the above criteria.

TABLE I
SUGGESTED DEBATE TOPICS AND POSITION QUESTIONS FOR TECHNICAL SUBJECTS STUDIED IN CS0.

Course material	Software design and testing
Debate topic	Software risks
Position questions	Do the benefits of computer technology outweigh the risks caused by poor software design or inadequate debugging? Do computer professionals have a social responsibility beyond just doing their job to see that their technology is used for the benefit of society?
Course material	Peer-to-peer networks
Debate topic	Digital copyright
Position questions	Is downloading copyrighted music stealing? Does the entertainment industry have the right to prevent the sharing and downloading of copyrighted media?
Course material	The Internet
Debate topic	Monitoring communication over the Internet
Position questions	What are reasonable expectations of privacy for e-mail? Is it ethical for an employer (university) to monitor an employee's (students') Internet usage and communication at work (school)?
Course material	Computer security
Debate topic	Hackers and malicious software
Position questions	If a hacker does not intend to profit from their actions, should their crimes be treated lightly? Alternatively, should their crimes be treated severely to deter other computer hackers whose intentions are not known?
Course material	Artificial Intelligence
Debate topic	Using computers to replace humans
Position questions	Are the goals of AI ethical? Who should be held responsible for the actions of an intelligent agent?

METHODOLOGY

I. Prerequisites

Students should first be educated in the fundamentals of the major ethical theories before beginning their study of ethics in computing [5], [13]. Simply stated, an ethical theory is a theory about what makes an action morally right or wrong. If one considers computer ethics as the way in which computers "pose new versions of standard moral problems and moral dilemmas" [14], then one can approach ethical issues in computing from the principles of ethical theories such as those in Table II. Students should then be exposed to the codes of conduct of computing societies, such as the *ACM Code of Ethics and Professional Conduct* and the *Software Engineering Code of Ethics and Professional Practice* by IEEE, and understand how to apply the appropriate guidelines to professional ethical concerns [7]. Additionally, students should be aware of the University's Acceptable Use Policy.

TABLE II
THE TWO MAJOR ETHICAL THEORIES.

Utilitarianism:	Consequentialist (goal-based) theory of ethics, in which one acts according to that which will result in the greatest good or happiness for the greatest number of people.
Kantianism:	Deontological (rule-based) theory of ethics, in which one acts according to duty or doing what is right regardless of the consequences.

Ethical theory and codes of conduct will be discussed in class. Web design, forum usage and Internet research tools such as search engines and the Duke University digital library can be taught in the beginning CS0 computer laboratory sessions without detracting from class time in the weeks preceding the beginning of the debates.

II. Process

The process by which the interactive ethics study will proceed is detailed below. A summary is provided in Table III.

TABLE III
SUMMARY OF DEBATE PROCESS.

1)	**Class discussion.**
2)	**Research.**
3)	**Position assignment.**
4)	**Forum discussion.**
5)	**Debate preparation.**
6)	**Quiz.**
7)	**In-class debate.**
8)	**Assessment.**
9)	**Final project.**

Class discussion. Immediately following the teaching of a technical subject or advancement, engage the class as a whole in a discussion of what ethical, social, and/or legal issues may arise as a consequence. Encourage the application of utilitarian and Kantian principles. Lead the discussion towards potential topics for debate and point out good and bad arguments. A subset of the students will be chosen for participation in the debate, on a volunteer or assignment basis.

Research. Debaters are to prepare a research document, based on class discussion, providing an in-depth assessment of 1) the specific technology involved, 2) the ethical, social, and legal implications, 3) a focused study of the topic for debate, to include at least three supporting and dissenting arguments, and 4) a list of references. The Internet will be used as a primary research tool, with the instructor providing a sample of online sources. Students prepare their document in a form viewable from the Internet (e.g. as a web page) that is accessible by the instructor.

Position assignment. Following submission of the research document, debaters are assigned an argumentative position for the in-class debate. The instructor may use the student submissions to select the debate teams.

Forum discussion. Debaters post their arguments on a class discussion forum. The arguments will be made publicly available to the class, and the judges will be allowed to ask clarification questions (to which the debaters must respond) or provide suggestions. The instructor uses the forum as an opportunity to provide feedback and ensure the arguments are relevant to the topic at hand.

Debate preparation. After the arguments are clarified and approved, the debaters prepare counterarguments and potential rebuttals for the upcoming in-class debate. The arguments will be in the form of a Web-viewable document that is accessible by the instructor. This information may also be made publicly available to the class, or kept private until the debate. At this stage the debate teams should work as a group, either by arranging meetings or engaging in online discussion to prepare and synchronize their arguments.

Quiz. An online quiz will be taken by all students immediately prior to the in-class debate to ensure the voters are prepared for informed discussion.

In-class debate. The debate will be conducted in class with opening arguments followed by a opposition argument followed by a rebuttal. The debate concludes with judges casting individual votes for winning team via the Personal Response System (PRS). Voting should be based on how well each debate team addresses their arguments and counterarguments.

Assessment. Online assessment forms for debaters and judges will be filled out in the days immediately following the debate while the information is still fresh in their minds. Questions for debaters will be on their general performance, why they felt they won or lost the argument, their individual quality of preparation and their satisfaction with the quality of preparation of the group as a whole. Judges will provide detailed reasoning for their decisions and feedback on the debaters' preparation and performance.

Final project. Debaters each assemble all individual and group research materials into a structured and unified Web presentation.

III. Timeframe

This process is designed to be completed within a month's time, outlined in Table IV. If a new process cycle is begun every two weeks, then five groups of students can complete the process in twelve weeks. Ideally, a debate team should contain 4-6 students, making our approach viable for class sizes of approximately 60 students.

TABLE IV
COMPLETION TIMEFRAME OF DEBATE PROCESS FOR DEBATER AND JUDGE LEVELS OF PARTICIPATION (ALL=INSTRUCTOR+DEBATERS+JUDGES).

Process Stage	Participation Level	Completion Time
Class discussion	All	1 day
Research	Debaters	1 week
Position assignment	Instructor	
Forum discussion	All	1 week
Debate preparation	Debaters	
Quiz	Debaters, Judges	1 day
In-class debate	All	1 day
Assessment	Debaters, Judges	1 day
Project assembly	Debaters	1.5 weeks

IV. Grading

The individual student's course project grade will be based on participation at both the debater and judge level over all debate cycles. Our grading convention is given in Table V.

TABLE V
CONTRIBUTION OF CUMULATIVE PROCESS STAGES AT DEBATER AND JUDGE LEVELS OF PARTICIPATION TO FINAL PROJECT GRADE.

Process Stage	% of Project Grade
Research paper	10%
Forum discussion (debater)	10%
Forum discussion (judge)	5%
Debate preparation	10%
Quizzes	10%
In-class debate (debater)	20%
In-class debate (judge)	5%
Assessments	5%
Final project assembly	25%

V. Scenario: Digital Copyright

One particular scenario concerns Peer-to-Peer file sharing and its societal and ethical implications. In discussing Peer-to-Peer systems, students learn about computer networks including the Internet and its history, network topologies, and distributed systems [15]. From there students can have informed discussion on the benefits and costs of a decentralized system versus the prior client-server model. With this technical background, students learn the answer to a number of questions regarding copyright:

Basics – What is the history of copyright and other forms of protection such as patents and trademarks? What are the implications for digital media?

Infringement – What are direct, contributory, and vicarious infringement? Is copyright infringement stealing?

Ethics – If material can be reproduced virtually for free, is there any harm in distributing it for free? Where do the rights of the copyright holder end and the end user begin?

The questions on the copyright basics are used in quizzes to test students' knowledge of the basic issues. The debate topic chosen is whether peer-to-peer file sharing is a legitimate use of university networks. The questions on infringement and ethics form the basis for the forum discussion and are used by the debaters in framing their positions.

IMPLEMENTATION

We have implemented the above approach in the Summer 2003 and Spring 2004 semesters. As the summer semester class size was small (< 10 students), all students participated in debates and the instructor served as judge. As a class project, the students were asked to submit a research essay and give an oral presentation on a debate topic of their choosing, followed by a question and answer session in which fellow classmates raised debatable issues. The students were first asked to read a collection of papers, including the *ACM Code of Ethics and Professional Conduct*, to introduce the ethical issues raised by computing technology and current trends in computer science. The class engaged in a moderated discussion and question/answer session about the readings and how to identify debatable issues and supporting and dissenting arguments for a position question. At the conclusion of the discussion, the students were asked to further research debatable issues in computing and select two topics they found both interesting and relevant to their lives outside the classroom. The following topics were selected by the students for debate: 1) Internet Monitoring in Colleges and Universities and 2) Digital Copyright. The debate teams were assigned at random and students were given a week for preparation. Each debate was scheduled for 30 minutes.

The spring semester course fully implemented the methodology described in this paper for a class of 66 students. The issues selected for debate were:

- **The Digital Divide.** The public should subsidize computer and/or Internet access for underserved areas and communities.
- **Software Design.** Software companies should be held responsible for damages due to buggy software.
- **Digital Copyright.** Peer-to-peer file sharing is a legitimate use of university networks despite whatever alleged copyright infringement occurs.
- **Security.** The act of gaining unauthorized access to computer systems (cracking) should not be criminalized assuming that there is no damage.
- **Privacy.** A university should be allowed to monitor university networks and connected computers for improper activity.
- **Artificial Intelligence.** Computers think.

Students were divided roughly evenly among the projects and side (for or against) based on interest. The teams of 5 or 6 presented their side in the in-class debate. The student presentations provided students with an opportunity to present in front of a medium-sized audience and develop their skills creating presentation materials. Each debate was designed to take half of a 50 minute class period.

A significant benefit of the debates in the spring semester was that the final projects were of higher quality than previous semesters without debates. Some of this better caliber of work is due to the longer and broader exposure to the issues. Students were required to do research well before the project due date. Furthermore, projects went beyond the customary shallow web search for sources to a more in-depth analysis of primary and secondary sources. The students were keenly aware of both sides of an issue and could do a better job building support for their position and addressing possible refutations.

One drawback was that students can be forced into presenting arguments that they do not themselves support, which can lead to a less satisfying experience. This was particularly apparent in the summer semester and could be attributed in part to the time constraints of the course (class met daily for a 6-week term) and the limited number of debates. In future semesters, we hope to present material related to the debate topics earlier, so students may feel more comfortable debating the other side of an argument after being able to explore the issues over a longer period of time.

Overall, the students found the activities involving social issues to be interesting, enjoyable, and relevant, as shown by their responses:

> *"The debates added an alternative perspective."*
>
> *"I liked the ethics discussions because they focused on real life issues with computers."*
>
> *"These articles sparked an interest for me into the world of computer science and made me realize that ethical issues pertaining to computer science have just as many implications to society as ethical issues that have been deemed as important in the past."*

Students were often amazed at what they *didn't* know:

> *"You never know when the OIT (Office of Information Technology) is going to break down your door and seize your computer!!!"*
>
> *"While I am a frequent computer user for normal tasks such as word processing, email, and Internet browsing, I was unaware of the programming aspects of the computer and how programmers have the ability to change our world for better or worse."*

The debates even appealed to many students lacking interest in the technical aspects of the course:

> *"I think the debates were both worthwhile and interesting. I personally like debate, and any time off from dry subroutines and algorithm design is awesome."*
>
> *"I always enjoyed the debates because it provided me with a chance to understand another side of computer science which I could handle without any programming skill."*

We are encouraged by our results thus far and plan to integrate our methodology into the CS0 syllabus. In the future, we would like to perform a substantive assessment of the effectiveness of this approach in engaging non-majors and students traditionally underrepresented in computer science.

CONCLUSION

Discussing the interplay of society and computing can promote the understanding of a student's rights and responsibilities and an awareness of their personal role in the discipline. This strategy is well suited for non-majors as it emphasizes research skills, written composition and oral presentation without detracting from the technical content of the course, and will furthermore make the class an enjoyable and satisfying learning experience and promote interest in future course offerings.

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