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ETHICS AND PERVERSIVE TECHNOLOGIES: A COLLABORATIVE APPROACH TO TEACHING

Kalpana Shankar, Kay H. Connelly
School of Informatics and Computing

Although pervasive computing and computer ethics are taught in numerous computing curricula, they tend to be taught separately without much reference to the other arena. This paper reports on the efforts of two professors, one a social scientist and one a computer scientist, to integrate components of their respective courses. Rationale for the pedagogy model, results of the courses, and reflections are included. The larger goal of this project was to develop a generalizeable pedagogical model for integrating technical and ethical education that focuses on educating technologists about the ethical dimensions of their work. Pervasive and mobile computing will only become more prevalent, so the authors anticipate a pressing need for educational materials and models for teaching in this arena.

INTRODUCTION

Technologies are being developed today using small, relatively inexpensive, wireless-enabled computers that have the potential to result in the near-omnipresence of information gathering and processing: a trend called pervasive or ubiquitous computing. The miniaturization of processors and sensors is ushering in an array of devices that can be embedded in clothing, appliances, carpets, food packaging, doors and windows, paperback books, and other everyday items which can be used to gather data about when and how (and possibly by whom) an item is used.

While the era of pervasive and ubiquitous computing has exciting potential and actual applications for commerce, health care, and other arenas, the fine-grained nature of data collection and widespread potential for use and misuse engenders numerous ethical issues for the maintenance of individual privacy and security, as well as so-far
unanticipated issues. Engaging designers and computer scientists in planning for and minimizing technological risks will become an increasingly important part of computing education.

While there is a growing body of literature on the ethical analysis of pervasive computing, there has been significantly less published on teaching in this arena. Thus, although pervasive computing and computer ethics are taught in numerous computing curricula, they tend to be taught separately. The larger goal of this project was to develop a generalizable pedagogical model for integrating technical and ethical education in a way that educates designers about the ethical dimensions of their work. Some of these are best addressed in formal training, so that they become part of the culture of researchers and engineers responsible for identifying needs and designing solutions. Certainly, there is a great deal of literature on the broader issues in teaching ethics to future computing professionals, so integrating the ethics of pervasive and autonomous information technologies into existent curricula and courses is not a stretch, although it remains challenging. Codes of ethics, including the Association for Computing Machinery's, outline responsibilities that professionals should have in their spheres of influence. Another approach to specifically inculcating values into the design process is espoused by proponents of Value Sensitive Design, a methodological approach to the design of technology that incorporates an iterative cycle of empirical research, design, implementation, and evaluation with an eye to the integration of human values beyond efficiency and usability into the process and product of design (Friedman).

**Motivation**

The authors became interested in teaching in this area through several interrelated experiences. As co-Principal Investigators on a National Science Foundation sponsored project, ETHOS (Ethical Technologies in the Homes of Seniors, which is investigating pervasive computing in the home and privacy/security implications for aging in place), they have worked for several years with students from different computing disciplines including computer science, human-computer interaction/design, and cybersecurity, as well as students from non-computing disciplines, such as applied health. The instructors' experiences with student researchers have suggested several gaps in computing education, particularly in pervasive computing and computer ethics. Many of the more technology-oriented students are unfamiliar
with and often unable to engage with the social and ethical implications of their work, while the less technical students are often unable to analyze technology for its ethical implications because they have an insufficient grasp of the capabilities of pervasive technology. These informal findings were made more concrete in the classroom, as Connelly teaches mobile and pervasive computing and Shankar regularly offers computer and information ethics courses.

A second impetus from the project derived from empirical research. In 2008, Oliver McGraw, an undergraduate Informatics major at Indiana University-Bloomington with significant coursework in anthropology and philosophy, conducted a qualitative study of design students studying pervasive computing in Connelly's class. He focused on the role of ethics in the design process and how and when the design students integrated thinking about the values their work embedded in their work processes. Using class observations and interviews with the students, he observed that the students tended to think of ethics in two ways: either as the work of the Institutional Review Board or something that was “added on” after the design was complete, usually through a brief discussion of privacy in the final report. This appeared to be the case even after several class discussions devoted to ethics in design. McGraw concluded that the “work” of ethical design and thinking was something that was performed by someone else, because the designers did not see themselves as needing to perform the work that ethicists would do.

**Class Design**

Building on these findings and concerns, Connelly and Shankar conceived of a more collaborative approach to teaching and getting students from different courses and sub-disciplines of computing to work together. Connelly, a computer scientist, designed the Pervasive Computing elective P535, and has been teaching it since 2003. Because of the project-intensive nature of the course, there is a limit of 24 graduate students who can take it each semester. In P535, the students perform a semester-long, team-based project in which they design and implement a pervasive computing application. Some teams spontaneously include ethical considerations when discussing and choosing possible designs, but the majority of them rarely think critically about the implications of their designs. Shankar, a social scientist, has been teaching computer and information ethics, 1453, at Indiana University since 2004 with usual enrollments of 20-25 students. The course was designed and regularly
taught by Shankar as a joint Undergraduate/Master's level course, but the vast majority of students taking the course have been undergraduates in the Informatics program. However, in the fall of 2009, 35 students enrolled in the course, all undergraduates. The sudden increase in enrollment is directly attributable to changes in the undergraduate curriculum of the Informatics program.

The instructors envisioned that undergraduate students from I453 could observe design sessions for grad student teams in P535, noting the extent to which the teams brought up issues of ethics without explicit prompting. The I453 students could bring their observations into their course for classroom discussions and write up their observations, then the P535 students could respond in their own project analysis. In this way, both sets of students would receive hands-on experience to foster an awareness of the implications of a design process that does not explicitly take ethics into account. If the ethics students could have evaluated the technologies in a more completed stage, this would have allowed both sets of students to evaluate the prototypes as a consumer who cannot see into the "black box" of design might, but this was not practical.

To execute this project, the two instructors:

1. Developed two lectures where both classes were brought together to discuss current topics in pervasive computing. These were based on two articles: one on Radio Frequency IDs (RFIDs) (Lockton and Rosenberg 2005) and one on the general issues of ethics in pervasive computing (Bohn, et.al).

The first lecture introduced the general domain of pervasive computing based on Welser’s original vision of pervasive computing, then spent the majority of the lecture discussing one particular pervasive computing technology: radio frequency identifiers (RFID). The lecture focused on the capabilities of the technology, and the ethical dilemmas such technology poses. An algorithm meant to address the privacy implications was introduced (Jules, Rivest and Szendro 2003) and discussed at length in small groups to determine if a technological solution could, indeed, address the ethical challenges introduced by RFID tracking. In this way, the ethics students were given an in-depth look at one particular technology and how it worked, while the pervasive students were introduced to the concept of ethics in the context of technologies they may actually choose to use in their projects.

The second lecture discussed pervasive computing more broadly by
examining the risks and moral hazards of computing across “borders” (and how pervasive applications address them). Physical, social, spacial, and temporal borders were introduced. Students were encouraged to brainstorm the kinds of problems that might arise when borders are crossed vis-a-vis pervasive technology and how designing for those problems through increased information symmetry, access, and transparency, and decreased persistence might alleviated them.

2. Introduced the project that would bring students from both classes together. The researchers’ collaboration on ETHOS suggested a natural scope for potential designs: pervasive and mobile technologies for senior citizens, particularly for aging in place. Because there were far more ethics students than design students, and because the researchers did not want to force students into working with the pervasive computing teams, volunteer teams were asked to work with the pervasive computing teams to analyze their designs and participate in their design discussions. These students were also given requirements documents and design documents that were part of the P535 deliverables. Other ethics students were asked to analyze prototypes from the ETHOS project that were already designed and built by previous classes of P535 students. These students were given requirements documents and design documents from those previous classes, but did not have the benefit of interviewing the student designers.

3. The I453 students observed and interviewed the ethics students. They were given copies of the P535 requirements and design documents, which had already been evaluated by Connelly. The ethics students were asked to participate in the design teams’ discussions at least once, preferably more, with as many of the team members present as possible. The students then submitted a one page summary indicating status of the project and what resources they were using, notes from any interviews or meetings with design teams, any problems they were encountering, any resources they needed from the instructors, and a brief workplan. Typical activities conducted in design sessions included brainstorming designs, writing personas, scenarios and storyboards to flesh out specific ideas, evaluating design concepts against the requirements determined earlier in the semester, sketching and constructing other low-fidelity prototypes.

4. The I453 students were then required to submit a five page double spaced report of their findings. The parts included a one page
summary of the prototype design and advantages/disadvantages of using the technology. Three pages were devoted to ethical analysis. Students were directed to use evidence from interviews with the design teams (where applicable), external references, design and requirements documents if appropriate, and use of ethical theory that studied in class. Shankar provided prompts for this section, including: What ethical considerations were taken into account during the design stage? What kinds of consequences might result from the use of this technology? What kinds of values are embedded in the design of this technology? What are the social networking, privacy, information access, and other themes that arise in discussion about this technology? The final page was devoted to suggesting a solution or solutions to making this technology more ethical. These solutions could be in the design stage, marketing, add-on products, or any other suggestions.

5. Several weeks later, after the ethics students had turned in their projects, all students were brought back together for a lecture to discuss approaches to “doing ethics,” primarily social impact and stakeholder analysis. The focus of this lecture was to introduce both groups to tools designers and technologists can use to make timely, ethical decisions. The instructors chose these approaches, as they were more accessible for the IS35 students than dialectic method. The topic was introduced using the Social Impact Statement tools and references (Huff 1996 and the Website http://computingassess.org/general_tools/sia/creating_sis.html). Since most of the students in both classes are professionally oriented, the instructors also discussed stakeholder and social analyses as components of codes of ethics for technology/computing professionals.

6. As part of their final report, the pervasive students wrote a two-page social impact statement for their project. Students were given the leeway to either respond directly to the report from the ethics students, or to perform their own analysis and prepare their own social impact statement. They were cautioned that they should make sure to address any valid criticisms from the ethics students in their statement, but were allowed to ignore an criticisms they thought were unreasonable. For every issue identified in their statement, the pervasive students were asked to discuss how the design could be changed to mitigate the risk, or explain why the design could/should not be changed.

Note that this combined curricula was in addition to the rest of the material taught in each course, and thus was only a minor piece of
the overall coursework for both classes. Figure 1 shows the approximate timeline over the course of the semester, along with project deadlines for the pervasive students.

**Figure 1: Semester timeline for overlapping course materials**

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<thead>
<tr>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
<th>Month 4</th>
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<tbody>
<tr>
<td>P535</td>
<td>P635</td>
<td>M453</td>
<td>P535</td>
</tr>
<tr>
<td>requirements doc due</td>
<td>design doc due</td>
<td>ethical analysis due</td>
<td>prototype final due</td>
</tr>
<tr>
<td>RFID/boundaries lectures</td>
<td>SI/S lecture</td>
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<td>report due</td>
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**RESULTS**

This section is drawn from the authors’ analyses of the requirements and design reports of the design students, as well as the final reports of both sets of students. The ethics students, for the most part, addressed some of the most apparent concerns raised by home-based pervasive computing—maintaining the privacy of the seniors for whom the technologies were designed while being useful and effective. In several papers, some students noted that technology could adversely affect elder-caregiver relationships (the latter concerns were not surfaced by the designers in their design team meetings nor in the final reports).

After the most obvious concerns were addressed, the ethics teams often came up with more spurious problems that were easily dismissed by the pervasive computing students. For example, one P535 team designed a video “picture frame” that could show videos of family members to each other with a dedicated and secure server running the application. The I453 team worried that videos could be seen by unintended viewers. The P535 team was understandably puzzled, since the purpose of the frame was to be seen and publicly visible. Simply placing it in another location would solve any perceived problems. In another case, the design team created a device that would detect falls on stairs. The ethics team was concerned that this would not work if the elder fell elsewhere, or if other people were in the house (which would negate the need for such a system).

Part of the challenge the P535 students encountered was the lack of technical understanding of the ethics students regarding the proposed technologies. Because their knowledge was incomplete or incorrect, some of the concerns they raised were based on misunderstanding of the
technology proposed. In the fall alert system, the ethics students were
concerned that false positives would annoy the user (whether
“annoyance” is an ethical concern is debatable). The design students
responded that the system “learned” gait and tread over time, which had
been part of the initial design documents and overlooked by the ethics
students. In another case, the ethics students misunderstood that a closed
data network was part of the design and thus inherently privacy-sensitive.

The first two issues suggest the third: because the ethics students
needed to find “enough” ethical issues, they often resorted to aesthetic or
preference-value concerns, or other issues that were not necessarily
ethical ones. The context of the design assignment made it difficult to
identify ethical issues in several cases and thus the ethics students found
themselves “fishing” for ethical dilemmas or worse, attempting to find
ethical dilemmas that would indicate that they had taken the ethics class.
For example, one team wrote, “If the [design team] had searched only for
the design that would make the most people happy, then we would be
seeing a utilitarian philosophy which tries to create ‘most happiness for
most people.’ However, they deepened their research and continued to
explore their design space.” The vagueness of this statement and its use
of esoteric language confused the design team. After all, they were
specifically focusing on one population (their “design space”) and not a
broader group and their own classes did not include any discussion of
utilitarianism and its relationship to computing.

Although the general tone of the design teams’ reports was
defensiveness (for reasons we speculate upon below), some design teams
did make some minor changes to their prototype specifications. These
tended to focus on ways to make the elders more autonomous with
respect to information flow. One team that had designed a medication
reminder system, received criticisms that removing human caregiving
from medication monitoring would alter, perhaps negatively, elder-
caregiver relationships. The design team countered that they had
specifically focused their design on seniors who live alone and that
caregivers would be able to concentrate on other dimensions of their
relationships with their loved ones without worries about medication
adherence. However, the team did suggest that caregivers could be
provided access to the medication regime only when the system detected
a pattern of missed medications on the part of the elder.

CONCLUSIONS

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CONCLUSIONS

This paper reports on the design and implementation of a teaching module on ethics in pervasive technology. Aside from the logistics of insuring that the courses were offered at the same time, room scheduling to bring both classes together, different class sizes and levels, the instructors faced deeper challenges that they had not fully anticipated in the design of their modules. Most glaringly, despite common readings and lectures, the two classes did not have parallel experience and background with respect to ethics or pervasive computing. Thus, the two classes did not have the vocabulary or frameworks to reach out effectively to work with the other class.

There are numerous changes that could be made for next iterations of this course. One of the challenges was in the way the both teams of students were steered in scoping their respective projects. Instead of focusing on the ways in which the design students “went wrong,” they instead could have focused on ways the design students “did right.” This approach would have dovetailed with the mindset of the design students, who did not see their designs as posing any such problems; instead, they felt that they taken care of everything as they should given the context of their projects. Instead, the ethics students could have reframed their analysis by beginning with asking: What have you done in developing your design to make sure that everything is as it should be (privacy protected, informed consent, etc.). In short, shifting from the negative (has something gone wrong?) to the positive (reporting on what the teams had done to protect privacy, enhance autonomy, and so on) might have engaged the moral imagination of the ethics students more effectively.

Allowing the design students a larger scope of projects might also engender more lively conversation and debate. The P535 students were directed to create projects that were specifically geared towards senior citizens living at home. This scoping had several consequences. The P535 students were prepared to consider senior citizens as a vulnerable population without significant technological expertise, but who wanted to use technologies in the home. This stereotyping (or persona development, to be more charitable) already predisposed the students to design somewhat benign prototypes for home use.

Also, it might also help to take steps to ensure that the ethics students understand the technology before preparing their analysis, perhaps by giving them instruction in reading design and requirement documents (something that was not done in this iteration). It might also
be useful for the design team to write a document describing the technology in terms lay people could be expected to understand before finalizing the design. Finally, the design students might be asked to introduce a subtle but non-trivial ethical problem into the design documents they share with the ethics students. This would encourage the design students to think about ethics in a creative way and test the ethics students.

In summary, the instructors would encourage other instructors in the computing fields to make the attempt to teach ethics collaboratively with their humanistic colleagues. In the largest sense, the ethical, legal, and social dimensions of emergent science and technologies are most effectively approached in a multidisciplinary fashion as experts in different dimensions of the problems under scrutiny come together to define the problems, frame the questions, and explore options. Teaching students to do the same and to respect and engage multidisciplinary perspectives on technological concerns is a worthwhile task.

NOTES

1The authors would like to thank Dr. Kenneth Pimple, Dr. Barbara Andrews, Dr. Chuck Huff, and attendees at the 2010 Workshop on Ethical Guidance for Research and Application of Pervasive and Autonomous Information Technology (PAIT) in Cincinnati, Ohio on March 3-4, 2010 for their helpful comments. An earlier version of this paper was presented at the Workshop on Ethical Guidance for Research and Application of Pervasive and Autonomous Information Technology (PAIT) in Cincinnati, Ohio on March 3, 2010.

2This material is based upon work supported by the National Science Foundation under award numbers HCC-0765676 and SES-0848037. Any opinions, findings, and conclusions or recommendations expressed in this presentation are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

3The “Social Impact Statement” language engendered some lively conversation among the ethics students. The framing of the ethics textbook used, Deborah Johnson’s Computer Ethics (4th Edition), emphasized a sociotechnical approach to information ethics and thus avoided the “social impact” language as technologically deterministic and not sufficiently nuanced to capture the complexities of technology and society. Many of the students had also taken an introductory social informatics class that critiqued “social impact” for many of the same reasons and instead were introduced to other models of social/technical interaction, such as co-shaping of technology and

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society and sociotechnical networks. These theories were not introduced to the pervasive computing students.

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