Collaborative Research: Educational Simulation for Computing and Information Ethics

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This document contains the one-page project summary and fifteen-page project description for our three-year collaborative proposal that was submitted to the National Science Foundation in April 2007 and awarded on August 23, 2007. Dr. Kenneth R. Fleischmann at the University of Maryland-College Park (College of Information Studies), Dr. William A. Wallace at Rensselaer Polytechnic Institute (School of Engineering), and I collaboratively co-wrote this proposal in order to obtain funding for a research program to develop, assess, and distribute an information ethics simulation and accompanying course. The list of references is omitted because of the space that it would use, however, I would be happy to provide it upon request. The project is currently underway, and thus far, the course has been developed, taught, refined, and taught again, and a total of ten cases have been developed, which will serve as the initial content for the simulation.

Educational Simulation for Computing and Information Ethics
Project Summary (Combined Research and Education Project)

Modern global society is increasingly reliant on computing and information professionals to serve key roles in creating, managing, and maintaining the global computing and information infrastructure that is critical to research, education, commerce, and quality of life. As such, computing and information professionals need to learn not only technical skills but also how to resolve ethical issues such as in/outsourcing, intellectual property, and information privacy. Working in the new global economy requires that computing and information professionals are able to consider the range of cultural values and ethical perspectives as represented by leading thinkers such as Aristotle, Bentham, Buddha, Confucius, Gilligan, and Kant. To broaden and deepen the ethical perspectives of computing and information professionals, it is essential to develop and teach courses in computing and information ethics as part of professional graduate programs in computer science and the interdisciplinary information field. Further, to enable current and future computing and information professionals to appreciate and understand the relevance of ethics in their work, it is necessary to find educationally motivating ways to engage graduate students in professional computing and information programs to consider key ethical issues. This study proposes to accomplish this goal through development and evaluation of an educational simulation for computing and information ethics that serves as the cornerstone for an innovative course focusing on the role of values and ethics in computing and information within a global society.

This study builds on the PIs' prior research, including NSF-funded studies of the ethics of computational models and educational simulations, as well as developing and testing a web-based ethical assistant and "ethical" software agents. The PIs' expertise includes ethical implications of computing and information; development of software for simulating ethical decision making; and the ethics of modeling.

The proposed study answers three research questions: 1) How do graduate students in a computing and information ethics course use educational simulation software to gain understandings of and hands-on experiences with important computing and information ethics issues such as intellectual property in a global society? 2) Does geographical co-location have an impact on use of the simulation in the context of an internationally-oriented computing and information ethics graduate course with a diverse range of students? and 3) Do students in a graduate-level computing and information ethics course benefit most from interaction with peers, or with the software agents developed through this project?

To answer these important questions, the PIs propose a three-year study. The first year focuses on the initial development of the simulation and the innovative course. The second year involves evaluation and refinement of the simulation and course, including direct comparisons of individual and group use and online and face-to-face use of the simulation. In the third year, the PIs complete final versions of the simulation and course and implement both at additional institutions, by working with the advisory board, presenting workshops at major computing and information education conferences, and distributing the simulation via the web. The external evaluator will help assess the success of the simulation and course.

Intellectual Merit: First, this study contributes to computing and information ethics education through the development and evaluation of a novel simulation and course for computing and information ethics. Second, this study extends the research reported in the literature that compare face-to-face and online education by generating new data that explore the impact of geographical co-location versus online context on the effectiveness of using an educational simulation for computing and information ethics. Third, this study compares interaction with other people and interaction with software agents in the context of an educational simulation for computing and information ethics.

Broader Impacts: This study provides a free and open-source simulation for computing and information ethics, allowing students both to participate in and learn from cases and to develop and implement their own cases that they can then share with peers. It involves the development of a novel and highly participatory course built around the simulation that will be implemented in professional computing and information master's programs across the country and the world. This study better prepares computing and information professionals to deal with ethical issues throughout their careers. The study provides financial support and research training for two undergraduate and two doctoral students.

Educational Simulation for Computing and Information Ethics
Project Description

1. Motivation

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

This case excerpt presents the reader with a potential ethical conundrum related to intellectual property within an international context. Unfortunately, computing and information professionals are ill-equipped in practice to deal with such scenarios. For example, Chuang and Chen (1999) found that in four different countries, including the US, computing and information professionals do not have sufficient educational opportunities to learn about computing and information ethics. It is important that students not only have the opportunity to learn about computing and information ethics, but also that they are exposed to a wide range of ethical perspectives (Clarkeburn et al. 2003). Computing and information professionals should be provided not only with technical training but also ethics education to prepare them to deal with computing and information ethics issues such as intellectual property, in/outsourcing, information privacy, and other ethical issues within an international context. One way to do this is to focus on the range of personal values seen as important in different cultures as well as to different people, and understand how these values are related to ethical decision-making.

In order to be successful in the delivery of ethics education, it is critical that professional Master's programs in computer science and the interdisciplinary information field[2] deliver engaging and substantive courses in computing and information ethics. To meet this need, this study involves the development and assessment of a computing and information ethics simulation focusing on ethical issues such as intellectual property within a global context. The design, development, and assessment of the simulation and the course occur incrementally, using the approach of user-centered design.

The first objective of this study is to build the simulation as part of an innovative course in computing and information ethics and support students' learning about others' values and ethical decision-making. The second objective is to determine the importance of geographical co-location of students using the simulation. The third objective is to compare the effectiveness of the simulation when used by students working with other students or individually, by interacting solely with software agents.

This proposal begins by reviewing the literature on developing an educational simulation for computing and information ethics; geography, culture, values and ethical decision-making; and learning about values and ethics from interacting with peers and ethical agents. The next sections detail relevant prior research projects by the PIs, including NSF-funded studies of the values embedded in computational models and the design and use of educational simulations, as well as research projects that result in ethical assistant software and "ethical" software agents. Next, the research questions and hypotheses are listed. After that, the research design is discussed in detail, including the design of the course, the simulation, and the cases, as well as the research team and advisory board, the sites, the research methods, the schedule, and the assessment strategy, including an external evaluator. Finally, the intellectual merit and broader impacts of the proposed research are discussed, along with an explanation of how the results of this work can be disseminated to directly influence ongoing research and educational efforts within the domain of ethics education, with an emphasis on computing and information ethics education.

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

[2] Here, the interdisciplinary information field refers to a diverse yet related range of degree programs in information science, studies, systems, technology, management, and related fields.

2. Project Rationale

2.1 Developing an Educational Simulation for Computing and Information Ethics

Computing and information ethics education benefits greatly from the work of pioneers such as Walter Maner (1980), Deborah Johnson (2000), Richard Spinello (1995, 2006), Herman Tavani (2004), and Chuck Huff (2003). Another important influence is the ImpactCS project, which has developed three reports that emphasize the role of ethics in computer science education (Huff and Martin 1995, Martin et al. 1996, Martin and Weltz 1998). More specifically, building upon the moral psychology literature,[3] Huff and Frey (2005) outline how teaching with cases in technical courses can support teaching practical ethics, and show that ethical decision-making is not rule-based, but instead uses metaphor, analogy, and narrative. Thus, using the case method allows students to play different roles leading to different intuitions, provides bases for future analogies and metaphors, and allows "safe-but-realistic" practice. Keefer (2005) provides principles for educators derived from the problem- or inquiry-based learning literature,[4] and suggests that it is important to use authentic cases, to require students to make decisions, to encourage self-reflection, to connect cases to specific learning outcomes, and to use collaborative learning.[5] Loui (2005) provides four examples of good practice: parsing a large problem into "bite-size" pieces, adjusting presentation of material based on interactions with students, use of active learning, and facilitating student cooperation. The proposed study plans to apply all of these important insights.

The use of computers in higher education can have a range of positive impacts. Timmerman and Kruepke (2006) find that student performance gains with computer-aided instruction are larger than with traditional instruction. Computer simulations, in particular, can provide beneficial learning experiences. For example, a meta-analysis of the results of 32 studies shows that simulations provide significantly higher cognitive gains than traditional teaching methods (Vogel et al. 2006). Bergin et al. (2002) find that simulations are effective in involving students more actively than traditional case presentation methods that are paper-based. Simulations help students take perspectives, consider tradeoffs, and come up with creative solutions (Bos et al. 2006). Finally, Darabi et al. (2007) find that simulation use that involves interactive problem solving outperforms working out examples in class. As Shneiderman (2002: 222) argues, "simulations open up your mind to possibilities, allow you to explore safely, and enable you to see complex relationships." Simulations are thus ideal tools to use for teaching ethical decision-making.

Pioneering research is already being undertaken in the design and evaluation of ethics education support systems, which are computer programs that are designed to help students to understand and appreciate ethics.[6] While existing ethics education support systems make significant contributions to ethics education, new areas of research remain to be explored. For example, since these systems tend to have static HTML-based interfaces, one fruitful direction would be development of a dynamic system with the potential to embed more interactivity by using a programming language such as Java. Second, most of these systems are built solely for individual use and decision-making, leaving opportunities for

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[3] For example, see Blasi (1980), Callahan (1980), Colby and Damon (1992), Johnson (1993), Keefer and Ashley (2001), Lakoff and Johnson (1999), Matthews (1987), May (1996), Oliner and Oliner (1988), Pinkus et al. (1997), Pritchard (1998), Werhane (1999), and Weston (2001).

[4] For example, see Bereiter (1992), Bereiter and Scardamalia (1989), Brown and Campione (1994, 1996), Brown and Palincsar (1989), Cognition and Technology Group at Vanderbilt (1992, 1993), Keefer (2002), Keefer et al. (2000), May (1992, 1996), National Research Council (2000), Resnick et al. (1992), Resnick and Collins (1994), Savery and Duffy (1995), and Zeidler (2003).

[5] Descriptive ethics models help students understand the factors that may affect decision-making (Banerjee, Cronan, and Jones 1998, Bateman et al. 2003, Bommer et al. 1987, Brady 1985, Brass et al. 1998, Carroll 1989, 1990, 1996, Ferrell and Gresham 1985, Ferrell et al. 1989, Fritzsche 1991, Hunt and Vitell 1986, Jones 1991, Jones and Ryan 1997, Loch and Conger 1996, Malhotra and Miller 1998, McDevitt and Van Hise 2002, Stead et al. 1990, Street et al. 2001, Strong and Meyer 1992, Trevino 1986, van de Poel and Royakkers 2007, Wotruba 1990).

[6] For example, see Goldin et al. (2001), Gotterbarn (2004), Maner (1998, 2002), McLaren and Ashley (1995, 2000), Sherratt, Rogerson and Fairweather (2005), and van der Burg and van de Poel (2005).

designing systems that allow groups of users to interact, or for individual users to interact with software agents, which could facilitate examination of ethical decision-making as a social process. Third, these systems have relatively simplistic and idealized relationships (if any) between values, criteria, principles, and decisions, rather than more complex and realistic relationships based upon empirically generated data. Fourth, these systems lack an iterative dimension, which would allow students to run and re-run a case to see how various combinations of individuals and their decisions within specific roles change the overall outcome. Fifth, these systems are not built primarily for use in conjunction with a computing and information ethics course. Finally, dissemination of these systems tends to be quite limited, which can be overcome through open-source distribution of software as well as accompanying course materials.

2.2 Geography, Culture, Values,[7] and Ethical Decision-Making

Both nationality and culture are linked to variations in ethical decision-making.[8] For example, Peppas (2002) finds significant differences in the ethical perspectives of Asians and Americans. Axinn et al. (2004) demonstrate the interconnectedness of culture and values. Recent research shows that there is a connection between personal and cultural values.[9] Further, recent research demonstrates that the effect of personal values across cultures affects ethical decision-making.[10] For example, Shafer et al. (2006) find differences among Americans and Chinese in their views regarding social responsibility and economic efficiency but also identify positive links between self-transcendence values and attitudes regarding socially responsibly behavior across the two countries. When comparing the values of people living in the US and the Middle East, Ford et al. (2005) discover that these two cultural groups differ significantly in terms of their social, political, and religious values. Students using a simulation could become more aware of these cultural differences; but whether it is more effective for students from different cultures to be geographically collocated or dispersed when using the simulation is an open question.

Overall, face-to-face and online education modes appear to be equivalent in terms of potential effectiveness. For example, a study comparing face-to-face and online education in career and technical education courses identifies no significant difference in student performance between online and campus courses (Benson et al. 2005). A survey comparing 532 faculty members' satisfaction finds that online

[7] Values can be defined as "evaluative beliefs that synthesize affective and cognitive elements to orient people to the world in which they live" (Marini 2000: 2828). The Rokeach (1979) Values Survey and the Schwartz Values Survey (1992, 1994) are two of the most commonly used instruments for studying values. There is also a significant literature on the role of values in the design and use of technologies (Borning et al. 2005, Barr, Biddle, and Noble in press, Barr et al. 2006, Brey 2000, Burmeister 2000, Cockton 2004, 2005, Davis 2006, Davis et al. 2006, Ellul 1964, Fleischmann 2003, 2004, in press, Fleischmann and Wallace 2005, 2006, in press, under review, Friedman and Nissenbaum 1993, 1994, 1995, 1996, 1997, Friedman 1996, 1997, 2004, Friedman and Borning 2002, Friedman and Freier 2005, Friedman and Grudin 1998, Friedman, Howe, and Felten 2002, Friedman and Kahn 1992, 2000, 2003, Friedman, Kahn, and Borning 2006, Flanagan, Howe, and Nissenbaum 2005, 2006, Hess 1995, 2001, Introna and Nissenbaum 2000a, 2000b, Johnson 1997, Johnson and Mulvey 1995, Johnson and Nissenbaum 1995, Kling 1978, 1983a, 1983b, 1984a, 1984b, 1996b, Mumford 1934, 1970, Nissenbaum 1998a, 1998b, 2001, 2004, 2005, Pearl et al. 1990, Schuler 1996, Sclove 1995, Shneiderman 1990, 1995, 1999, Silver 2000, Star and Ruhleder 1996, Winner 1977, 1986, 1993)

[8] For example, see O'Fallon and Butterfield (2005), Ford and Richardson (1994), Ford et al. (2005), Sims (2006), Sims and Gegez (2004), Hisrich et al. (2003), Peppas (2002), Robertson et al. (2002), Aupperle (1984), and Ahmed et al. (2003).

[9] For example, see Fischer (2006), Fischer et al. (2007), Kemmelmeier et al. (2006), and Smith et al. (2002).

[10] Research also demonstrates the presence of a relationship between values and ethical decision-making in general (Abdolmohammadi and Baker 2006, Allen and Davis 1993, Ashkanasy et al. 2000, Connor and Becker 2004, Feather 1988, Fritzsche 1995, Fukukawa et al. 2007, Lin and Ding 2003, Robin, Reidenbach, and Forrest 1996, Roozen et al. 2001, Shafer et al. 2007, Singhapakdi and Vitell 1993).

education performed better for five education goals, face-to-face education led to better results on three goals, and two goals were toss-ups (National Educational Association 2000). Stern (2004) argues that student motivation and course design are more important factors in determining educational effectiveness than the distinction between face-to-face and online learning. Finally, a study aiming to overcome limitations of previous research on this comparison finds that, in harmony with the existing literature, there is no significant difference in the effectiveness of face-to-face versus online education (Carey 2001).

However, a thorough examination of the relevant literatures does not reveal any studies that comparatively examine use of an educational simulation in both online and classroom-based courses. Thus, there appears to be a gap in the literature in terms of comparison of face-to-face versus online use of educational simulations. Certainly the above literature is a good starting point, but there is a need to conduct additional research to answer this question in the specific case of educational simulation use. Further, for the specific example of ethical decision-making, the literature on cultural values discussed above clearly indicates that there is likely to be a correlation between geographical co-location, as would be the case for face-to-face teaching, and similarity of values, especially if the online students are not geographically co-located. Thus, students in online courses may likely be exposed to a wider range of values, although this difference may be confounded by the compositions of the online and face-to-face courses, especially if face-to-face courses contain more international students than online courses, considering the large number of international graduate students in computer science and the information fields. Overall, geographical co-location and cultural values are important considerations for understanding use of the simulation in online and face-to-face courses. Indeed, these are understudied yet important in the context of an educational simulation or a course for computing and information ethics, providing a specific opportunity for improving the understanding of computing and information ethics education while also beginning a line of research that can be extended to other types of ethics education, as well as development and use of educational technology and educational evaluation in general.

2.3 Learning about Values and Ethics from Interacting with Peers and Ethical Agents

It is also important for this study to look at research to date on individual versus group learning, as well as learning that involves interaction with software rather than other people, a topic which has not received attention to date within the domain of computing and information ethics education. The literature on group learning, which includes sub-literatures on cooperative learning and collaborative learning, has found that group learning has an overall advantage over individual learning in a variety of aspects. Johnson et al. (1988) and Slavin (1980) both find that group learning is more effective not only for achievement but also for broader aspects of education. Skon et al. (1981) find that group use improved student learning in comparison with individual learning. A meta-analysis of 46 studies and 63 relevant findings focusing on individual and group learning concludes that 55 of the findings favored group use, while only eight of the findings favored individual use (Qin et al. 1995). A similar meta-analysis by Springer et al. (1999) finds that group learning led to significantly better learning outcomes than individual learning within the domain of science, technology, engineering, and mathematics education. The literature on individual learning versus group learning thus finds an overall advantage in favor of group learning; whether this applies to computing and information ethics education is an open question.

The literature on individual versus group use of educational simulations has also found an overall advantage in favor of group learning. For example, in a computer skills course at the undergraduate level, Keeler and Anson (1995) find that group use of educational simulations improves learning and reduces computer anxiety in comparison with individual use. Similarly, in a study of recursive programming, Jehng (1997) finds that group use led to better learning outcomes than individual use. By observing young students learning at computers in small groups, Crook (1994) finds that computers stimulate collaboration and social engagement. In a study of a high school physics class, Goldman (1996) concludes that group use of computers among students promotes active engagement with science.

The most interesting feature of the comparison of individual and group use of educational simulations is that while earlier studies demonstrate that there is a significant benefit to group use of educational simulations, the reality is that most educational simulations are designed for individual use. In

addition, educators historically favor individual activities over group activities, especially in the case of computer use (Crook 1987). Indeed, educational simulations explicitly designed for group use are the exception (e.g., Tobin and Dawson 1992) rather than the rule. Johnson and Johnson (2004) list five reasons for educators' reluctance to use group learning: believing that students are meant to work individually; unwillingness to be responsible for others; not understanding how groups work; fear of failure of groups; and the time and effort necessary to incorporate group work. In the case of group use of educational simulations, a sixth factor should be considered: the human-computer interaction model of one user per computer. As a result, educators are reluctant to embrace group use of educational simulations. Clearly, researchers need to make educational simulation designers as well as educators aware of the data supporting group use of educational simulations. Further, it is important to extend this finding to the design and evaluation of an educational simulation for computing and information ethics.

This study extends research directions from the educational technology literature to computing and information ethics education. To date, software agents are primarily considered or used in a tutorial or supporting role.[11] Studies are now investigating sociability, personalization, believability and animation.[12] Agents are used to some extent in the development and evaluation of educational games.[13] Studies provide guidance for design and evaluation of such agents.[14] However, use of the multi-agent concept has been minimal.[15] In summary, most work with software agents in the educational technology community uses agents as tutors or assistants as opposed to participants in an interactive simulation. Thus, it is useful to investigate how users can interact with software agents in educational simulations, especially within the context of being exposed to different values and ethical decision-making rationales.

3. Research to Date

This section summarizes four prior and ongoing research projects conducted by the PIs that directly contribute to this study. Specifically, the first subsection details an NSF-funded study by Fleischmann and Wallace of the ethical implications of values embedded in computational models. The second subsection describes NSF-funded research by Fleischmann on the design and use of educational simulations. The third subsection discusses research by Robbins and Wallace that involves developing and testing a web-based ethical assistant, while the fourth subsection shares research by Robbins and Wallace leading to developing and testing software-based "ethical" agents. All four of these projects make important contributions to the proposed research and demonstrate the complementary expertise of the research team.

3.1 Ethical Implications of Values Embedded in Computational Models

Two of the PIs of the proposed study, Fleischmann and Wallace, have an ongoing NSF-funded study that examines the role of human values in computational modeling. Specifically, this study focuses on how human values influence and are influenced by the design and use of computational models, how human values shape and are shaped by professional and organizational culture, and how these values determine

[11] For example, see Aleven et al. (2004), Bello and Bringsjord (2003), Chou et al. (2003), Choy et al. (2005), Constantino-Gonzalez et al. (2002), Craig et al. (2004), Day et al. (2005), Dimitrova (2003), Holmes (2007), Hubal et al. (2001), Kabassi and Virvou (2003), Imberman (2005), Manos and Virvou (2003), Marin et al. (2004, 2005), Uresti and du Boulay (2004), Virvou and Alepis (2003), Virvou and Manos (2005), McLaren et al. (2005), Olguin et al. (2000), Soller et al. (2005), Tedesco (2003), Vizcaino (2005), Virvou et al. (2003), and Yang et al. (2005).

[12] For example, see Bull et al. (2003), Cooper (2003), de Carolis et al. (2006), Dirkin et al. (2005), Dunsworth and Atkinson (2005), Moundridou and Virvou (2002), and Robertson et al. (2004).

[13] For example, see Agostino et al. (2005), Virvou et al. (2002a, 2002b, 2004a, 2004b, 2005, 2006), and Virvou and Katsionis (2003).

[14] For example, see Amory (2001), Baylor (2001, 2004), Buendia-Garcia and Diaz (2003), Mahmood and Ferneley (2006), McNaught and Amory (2001), Robertson and Good (2003), Shifflet and Brown (2006), Shortridge and Sabo (2005), Westbrook and Braithewaite (2001), and Virvou et al. (2005).

[15] For example, see Baylor (2002), Baylor and Ebbers (2003), and Morozov et al. (2004).

and are determined by the success of the computational modeling process and of computational models as products. This project builds upon earlier collaborations on the importance of transparency in the design and use of computational models (Fleischmann and Wallace 2005) and the ethics of modeling (Wallace and Fleischmann 2005), as well as twenty years of research by Wallace (1994) on the ethics of modeling.

The findings of this ongoing study (Fleischmann and Wallace 2006, in press, under review), which adopts a case study approach to data collection and analysis, support the need for the proposed study by demonstrating the importance of understanding ethics and values for a specific subset of computing and information professionals. Further, these results demonstrate that current educational efforts are not sufficient, as computational modelers feel that they have not had adequate opportunities for ethics education in their past experiences in computing and information degree programs. Finally, this prior research also contributes to the proposed study through the generation of cases to be used in the simulation, which grounds the simulation in empirical data from this research to date by two of the PIs.

3.2 Design and Use of Educational Simulations

PI Fleischmann's focus on the design and use of educational simulations began with an NSF Graduate Research Fellowship and an NSF Dissertation Research Improvement Grant. This NSF funding allowed Fleischmann to complete a case-study-based dissertation on the ethical, social, cultural, and political dimensions of the design and use of educational simulations. The results of this study (Fleischmann 2003, 2004, 2005, 2006a, 2006b, in press, under review) demonstrate that human values play an important role in the design and use of educational simulations. The study also identified online versus face-to-face use and individual versus group use of educational simulations as important areas for additional research, especially in the context of study of values and ethics related to computing and information education.

3.3 Developing and Testing the Ethical Assistant Software

A prior project by two of the PIs, Robbins and Wallace, involves developing and assessing a decision support system that helps a student consider an ethical problem from new and different perspectives (Robbins, Wallace, and Puka 2004). The decision aid is web-based and provides content that summarizes and simplifies five of the leading moral philosophies: the ethic of care (Gilligan 1977), egoism (Rand 1964), virtue ethics (Aristotle 350 BCE), categorical imperative (Kant 1785), and utilitarianism (Bentham 1789, Mill 1863). The intent was to make the philosophies transparent, as suggested by Fleischmann and Wallace (2005). The specific ethical dilemma used was the Pharmanet case (Chee and Schneberger 1998, Schneberger and Chee 1999), which asks a reader to consider how to handle the prospective implementation of a widely accessible database of pharmacy prescription records.

This prior research demonstrates that web-based ethical decision aids can be built and used, and can improve the decision-making of students confronted with cases in a laboratory environment (Robbins et al. 2004) and reports information about the relationships among value types, ethical ideology dimensions, reasoning criteria, and decisions made by individuals resolving an ethical dilemma (Robbins 2005). This prior research contributes to the proposed study by serving as a roadmap for developing the educational simulation and identifying relationships between specific ethical decisions and values.

3.4 Developing and Testing Ethical Software Agents

Another important prior study by Robbins and Wallace involves the design, development, verification, and validation of a computational model of a group of software agents solving an ethical problem (Robbins 2005). For this study, the software agent paradigm is used in tandem with the concept of practical reasoning (Wellman 1999, Wallace 2001). In the context of artificial intelligence, an agent is a computer system that is capable of autonomous action and that interacts with other agents (Wellman 1999). Resolving ethical problems requires considering criteria, autonomy and sometimes, interaction. Software agents can consider criteria, act autonomously, and interact with other agents (virtual or human).

This research demonstrates that a software agent can mimic the practical reasoning-based resolution of an ethical dilemma (Robbins 2005) and contributes to the proposed study by serving as a prototype for the agents to be used in the simulation. These agents are based upon the practical

application of moral philosophies explored in this research, including ethics of care, egoism, virtue ethics, the categorical imperative, and utilitarianism. These agents allow individual users to run the simulation in a simulated group setting and also allow users to learn about the effects of interacting "ethical" agents.

4. Research Questions (RQs) and Hypotheses (Hs)

RQ1 How and why do graduate students in a computing and information ethics class use educational simulation software to gain understandings of and hands-on experiences with important computing and information ethics issues such as intellectual property in a global society?

H1a Graduate students can use the simulation software to better understand moral philosophies.

H1b Graduate students can use the simulation software to better understand the relationship between their own and others' values and ethical decision-making.

RQ2 Does geographical co-location have an impact on graduate students' use of the simulation in the context of an internationally-oriented information ethics course?

H2a Geographical co-location is more effective [than geographical dispersion] for graduate students learning about moral philosophies.

H2b Geographical co-location is more effective [than geographical dispersion] for graduate students learning about relationships among values and reasoning criteria, reasoning criteria and decisions, and values and decisions.

RQ3 Do graduate students benefit most from interaction with peers, or with the software agents developed through this project?

H3a Graduate students benefit more from interaction with peers [than with software agents] when learning about the relationships among values and reasoning criteria, reasoning criteria and decisions, and values and decisions.

H3b Graduate students benefit more from interaction with software agents [than with peers] when learning about moral philosophies.

5. Project Plan

This study involves user-centered design of an educational simulation as part of a new type of course in computing and information ethics education. This section outlines the course, the software, and the foci of the cases used in the software. It also describes the research team that is conducting the study, the primary sites where the software is used and assessed and the students who use and assess the software, the research methods to be used for data collection and analysis, the schedule, and the assessment strategy.

5.1 The Course

This study involves the development of a course on computing and information ethics that is novel in terms of the mechanism through which it is taught (the educational simulation to be developed), the range of timely and appropriate content areas (including particular emphasis on current issues such as intellectual property), and the international scope of the course (building on the notion of ethics and values as culturally constructed). This course places special emphasis on the mutually constitutive relationship between information technologies and human values, as well as the culturally situated nature of both information technologies and human values. In teaching this course, the PIs create an environment that allows graduate students to share their diverse cultural values and ethical decision-making processes by designing the simulation and the course for a multicultural audience. This course serves to situate key ethical issues related to computing and information ethics, such as intellectual property, in an international context. The initial course uses Mason's (1994) covenants with reality and values as well as Fleischmann and Wallace's (2005) covenant with transparency. It also builds upon Mason's (1986) four issues of the information age: privacy, accuracy, property and accessibility. A list of the course topics is provided in Table 1 to give an overview of the content of the initial design of the course.[16]

[16] The course, like the simulation, is refined over the duration of the study through refinements based on an iterative process of development and evaluation.

Topic 1	Technologies and Values as Culture-Specific
Topic 2	Ethical Implications of the Global Computing and Information Economy
Topic 3	Overview of Ethical Theories
Topic 4	Covenants with Reality, Values, and Transparency
Topic 5	Censorship
Topic 6	Intellectual Property
Topic 7	Stealing and Sharing Information
Topic 8	Information Privacy
Topic 9	Information Security
Topic 10	Software Reliability and Accountability
Topic 11	Globalization
Topic 12	Outsourcing
Topic 13	The Global Digital Divide
Topic 14	Professional Ethics

Table 1: Initial List of Topics for the Computing and Information Ethics Course

5.2 The Software: SIMULATE

Simulation for [Computing] and Information Master's [Students] to Understand, Learn, and Apply Teamwork and Ethics (SIMULATE), is a case-based learning tool that allows students to work individually or in groups including other students and/or software agents to resolve ethical dilemmas. SIMULATE presents students with ethical dilemmas and students then choose to take one or more roles within the case or assign the roles to software agents that represent specific ethical perspectives. SIMULATE can be used in face-to-face or in online courses and exposes students to a variety of ethical principles, but also creates an environment where students can consider the relationships of values and ethical decision-making. The process that students use to interact with SIMULATE is shown in Figure 1. Please note that although the software has robust technical capabilities such as allowing mixed groups of multiple students and multiple agents, as well as allowing students to play multiple roles or to observe the decisions of other students and/or agents, the evaluation of SIMULATE in this study focuses on direct comparison of individual use of SIMULATE by a single student interacting with software agents and group use of SIMULATE by groups of students each playing different roles. Study of other combinations of students and/or agents is beyond the scope of this study given limitations in time and funding, however there is great potential for additional research on these mixed and alternative modes of using SIMULATE, especially given that SIMULATE is to be freely distributed as open-source software for other researchers and educators to use, modify, and evaluate in subsequent studies. SIMULATE can also have a simple user interface, allowing ethics educators in other fields to enter additional non-computing and information ethics cases (e.g., biology, engineering) into the simulation for use in their ethics classes.

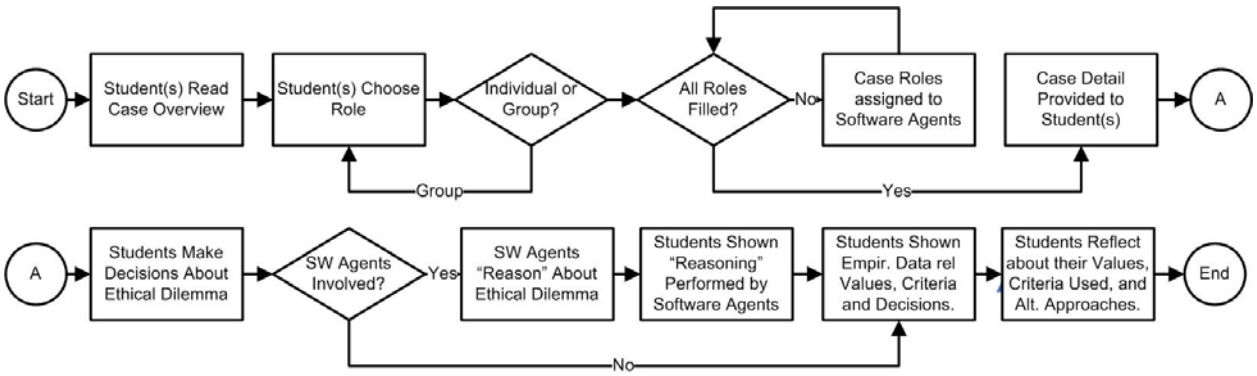

Figure 1: Process that Students Use to Interact with SIMULATE

Use of SIMULATE begins with a brief description of the roles available within a specific case. Each student can select a role. For exposition purposes, we now refer to the Pharmanet case (Chee and Schneberger 1998, Schneberger and Chee 1999) that centers upon patrons' privacy, social benefits, and rights of professionals in the context of the hypothetical implementation a province-wide pharmacy prescription record database in British Columbia. In this case, the roles include the Minister of Health, the president of the British Columbia Civil Liberties Association, the project manager of the Pharmanet implementation project, and the president of the Pharmacists' Association. Students either interact with their peers with multiple students playing the various roles in the case or an individual student can select software agents to play roles in the case. The software agents represent a wide range of ethical perspectives from across the globe such as Aristotle, Confucius, Buddha, Kant, Bentham, and Gilligan. The student is then presented with a brief description of a case related to computing and information ethics. Again, using the Pharmanet case, the student is briefed as to the context (1994, British Columbia) and the benefits or risks for various stakeholders (decreased adverse drug interactions, reduced fraudulent prescription fills for illegal uses, and streamlined billing) as well as concerns of the various roles (balancing multiple factors, intrusion into professional practices).

Next, the student is asked to make an ethical choice based upon the role and case provided. Based on the student's answer, the next screen provides feedback to individual students about the values embedded in their answers, helps them understand their decision, and explains how their decision is related to their values. This interaction stimulates users to think about criteria they use to draw conclusions. The simulation also shares with the users an empirical finding from an earlier experiment. The linking of the criteria used and associated values encourages thought about the linkages of personal values and the use of criteria when resolving ethical conflicts.

SIMULATE then shows the student the choices faced by other students (or software agents), their decisions made, and a reporting of the empirical relationship between the decisions made, values, criteria used, and/or the built-in "reasoning" of software agents based upon moral philosophies. Finally, the overall outcome of the scenario is displayed, with an explanation of how this outcome was a result of the decisions made by the different roles in the case, which were played by students or software agents.

The programming environment used to create SIMULATE is the Java programming language and JADEX BDI Agents. Advantages of Java and JADEX include cross-platform compatibility, suitability for the development, documentation, and extension of open-source freeware, the widespread use of Java, and Java's libraries of graphical user interface (GUI) source code. SIMULATE is to be made available to other educators and students as open-source freeware, allowing them to freely download, configure, use, and modify the software, and Java is suitable for this purpose because tools for Java software development are freely available on the Sun Microsystems website. Finally, Java has built-in capabilities to build GUI features, making SIMULATE easier and more enjoyable to use.

5.3 The Cases: Access, Ownership, Earning, Privacy, and Quality

A key component of SIMULATE is the library of cases that support the use of the software. The development of a range of short cases with accompanying roles is one of the significant aspects of the creation of SIMULATE. In addition, SIMULATE provides data to students about past student's values, criteria, and decisions about these cases. SIMULATE's cases are developed from several sources. While each case has a focal topic (see Table 1), each also ensures the opportunity for the student to consider multiple ethical perspectives in the frame of the covenants with reality, values, and transparency.

One important case for this study is the Pharmanet case (Chee and Schneberger 1998, Schneberger and Chee 1999). Based upon empirical data from research to date by the PIs, the major issues in this case include personal privacy, the opportunity to reduce adverse drug interactions and illegal prescription refills, and the potential effect of this system on the professional practices of pharmacists. Extensive research has been performed on this case to link value types, ethical ideology dimensions, reasoning criteria, and decisions (Robbins et al. 2004, Robbins 2005, Robbins and Wallace in press). Based on these data, it is possible to provide students with empirically validated analysis of others who came to the same decisions and how this information might stimulate a student's self-reflection about

values and ethical reasoning. By providing students with the results of these analyses, it is hypothesized that students are able to better understand the relationships between their own values and use of criteria, as well as begin considering the diversity of possible values, reasoning criteria, and potential decisions in any ethical dilemma. The students also benefit when they see traditional moral philosophic approaches dynamically applied when software agents play case roles.

The computing and information ethics literature is another source for cases.[17] During the study, data are collected about student values types, reasoning criteria, and decisions, making it possible to connect decisions to these other factors as was performed in the Pharmanet case described above.

Finally, many of the cases used in SIMULATE are developed based on data from an ongoing NSF-funded study that is being conducted by two of the PIs of this proposal (Fleischmann and Wallace). As discussed above, this study involves multi-method investigation of computational modeling within different organizational cultures. Data collection has already been completed for the corporate research laboratory and is underway for the academic and government research laboratories. Additional cases based on these data can be incorporated into SIMULATE. For example, one case would present students with an ethical dilemma in which an employee must decide how to confront racism related to outsourcing. Another case would ask the student about the balance between honesty and self-censorship in choosing whether or not to present a direct superior with disappointing news about the accuracy of a computational model. These cases can allow the researchers to apply their own findings to developing educational cases that are useful both within and beyond SIMULATE.

5.4 List of Key Personnel: The PIs, Students, Advisory Board, and External Evaluator

This project is led by a research team of three PIs at three different institutions with extensive experience in conducting collaborative research projects involving two or three members of the research team (e.g., Kelton, Fleischmann, and Wallace in press, Fleischmann and Wallace 2005, 2006, in press, under review, Robbins, Fleischmann, and Wallace under review, Robbins and Wallace in press, Robbins, Wallace, and Puka 2004, Wallace and Fleischmann 2005, Willemain et al. 2003). Collectively, the three PIs hold ten degrees in nine fields: computer science, anthropology, science and technology studies, finance, accounting, information technology, engineering science, chemical engineering, and management science. Two of the PIs (Fleischmann and Wallace) have prior funding from NSF, both individually and collaboratively.

PI Kenneth R. Fleischmann is an assistant professor in the College of Information Studies of the University of Maryland, College Park. He is also a member of the Human-Computer Interaction Laboratory of the University of Maryland. His doctoral dissertation, "Exploring the Design-Use Interface: The Agency of Boundary Objects in Educational Technology," examined the values embedded in educational computer simulations and their ethical implications, was funded by an NSF Graduate Research Fellowship and an NSF Dissertation Research Improvement Grant, and so far has directly led to five peer-reviewed journal articles to date (Fleischmann 2003, 2005, 2006a, 2006b, in press). He also has experience teaching information ethics at the graduate level.

PI Russell W. Robbins is an assistant professor in the School of Computer Science and Mathematics of Marist College. His doctoral thesis, "Understanding Individual and Group Ethical Problem Solving: A Computational Ethics Approach," involved the development of two important software products, the ethical assistant and "ethical" agents, and understanding 30 prescriptive and descriptive ethics theories. His professional experience includes eight years of teaching, four years of employment at IBM, and co-founding and serving as president of a company that developed information systems for agencies that serve individuals with developmental disabilities.

PI William A. Wallace is a professor in the Department of Decision Sciences and Engineering Systems at Rensselaer Polytechnic Institute. He has over forty years of professional experience as a

[17] For example, see Burmeister (2000), Johnson (2000), Johnson and Nissenbaum (1995), Schultz (2006), Spinello (2002), Spinello and Tavani (2004), Tavani (2004), as well as websites that contain cases for computing and information ethics such as www.onlineethics.org and computingcases.org.

computational modeler, and has conducted research on the ethics of modeling for over twenty years. Wallace has received extensive support from the National Science Foundation on research projects including the ethics of modeling, and results from this funding include an edited volume, *Ethics of Modeling*, and an interactive distance video workshop on the same topic. Wallace is also co-founder and editor emeritus of the journal *Computational and Mathematical Organizational Theory*. Wallace's extensive experience as a researcher and educator and his influential research in computing and information ethics serve as vital assets for this study.

This study also provides training and financial support for two doctoral students and two undergraduate students. At the University of Maryland, one doctoral student is supported for two academic years and three summers. At Rensselaer Polytechnic Institute, one doctoral student is supported for three summers. At Marist College, two undergraduate students are supported for one year each. The doctoral students receive training in interface design, creating a literature review, writing ethics cases, course development, and quantitative and qualitative data collection and analysis. The undergraduate students receive training and practical experience in requirements analysis, user-centered design, object- and agent-oriented programming, software reviews, and acceptance testing. Strong efforts are made to recruit students from underrepresented minority groups to serve as members of the research team.

An advisory board provides the research team with continuous feedback used to improve and refine the study. The advisory board meets with the assembled research team once per year at the University of Maryland to provide feedback on the progress made in the past year and the activities planned for the next year. The advisory board represents a range of expertise within the domains of ethics education and computing and information ethics. PI Wallace serves as the liaison between the research team and the advisory board, which includes Deborah Johnson, Keith Miller, and Ben Shneiderman.

Deborah G. Johnson is the Anne Shirley Carter Olsson Professor of Applied Ethics at the School of Engineering and Applied Science at the University of Virginia. She is a philosopher specializing in practical and professional ethics, focusing in particular on the ethical and policy issues surrounding computer and information technology. She is the author/editor of six books, including the popular textbook Computer Ethics, which is now in its third edition, and has written over 60 published papers. She co-edits *Ethics and Information Technology*. She is a past president of the Society for Philosophy and Technology as well as the International Society for Ethics and Information Technology (INSEIT).

Keith W. Miller is a Professor of Computer Science at the University of Illinois at Springfield. He has published research on the topics of computer ethics education, online education, and moral agents. He has also conducted NSF-funded research in the area of computer ethics education. Graduate computer science courses that he has taught include Ethics of Computing and Computers, Security, and Ethics. He has recently been appointed as the Senior Associate Editor of IEEE Technology & Society, and takes over as the Editor-In-Chief in December 2007.

Ben Shneiderman is Professor of Computer Science, Founding Director (1983-2000) of the Human-Computer Interaction Laboratory, and Member of the Institute for Advanced Computer Studies and the Institute for Systems Research, all at the University of Maryland at College Park. He is a Fellow of the ACM and the AAAS, and received the ACM CHI (Computer Human Interaction) Lifetime Achievement Award in 2001. His book *Leonardo's Laptop: Human Needs and the New Computing Technologies* won the IEEE 2003 award for Distinguished Literary Contribution. He has co-authored two textbooks, edited three technical books, and published more than 200 technical papers and book chapters.

Finally, as the external evaluator, Davina Pruitt-Mentle provides an outside perspective on the success of the simulation and the course. She is the Director for Educational Technology Policy, Research, and Outreach within the College of Education of the University of Maryland, and Director of the Cyberethics, Cybersafety, & Cybersecurity (C3) Institute. She has extensive experience in the research, development, and delivery of educational media, including computer software, multimedia, distance learning, and print materials. She teaches graduate courses on a wide range of technology-related topics, including cyberethics. She has also been appointed to serve on the K-16 Maryland Committee on Library Information Literacy and Ethical Use. She is to complete and defend her doctoral dissertation in educational technology policy at the University of Maryland in the summer of 2007.

5.5 List of Partnering Organizations: Maryland, Marist, and Rensselaer

The partnering organizations are the University of Maryland (the College of Information Studies and the Cyberthics, Cybersafety, & Cybersecurity Institute), Marist College, and Rensselaer Polytechnic Institute. Letters from the partnering organizations are appended as supplementary documents to the proposal.

The simulation and course are tested in five professional graduate programs in three institutions: the Master's in Information Management and Master's of Library Science programs at the University of Maryland, a public research university; the Master's of Computer Science and Master's of Information Systems programs at Marist College, a primarily undergraduate institution; and the Master's in Information Technology program at Rensselaer Polytechnic Institute, a private technological institution.

It is also important to implement and evaluate SIMULATE and the affiliated course at additional research sites. The advisory board, presentations and workshops at conferences, and web portals all help to publicize SIMULATE and the course, making it possible to encourage diffusion of SIMULATE to additional institutions and Master's programs. Through these opportunities, educators at other institutions are encouraged to adopt the course and the SIMULATE software and to revise them to fit their needs.

5.6 Evaluation Plan

Three types of assessment are used to evaluate the project. First, the advisory board gives guidance about the ongoing process, by reviewing the progress to date in the previous year and the planned activities for the following year. Second, the external evaluator evaluates the educational effectiveness of SIMULATE and the course (see Figure 2). Finally, the peer review process at journals and conferences provides validation of the research. The three components of the assessment strategy are interconnected and synergistic, and provide complementary feedback to the research team throughout the study.

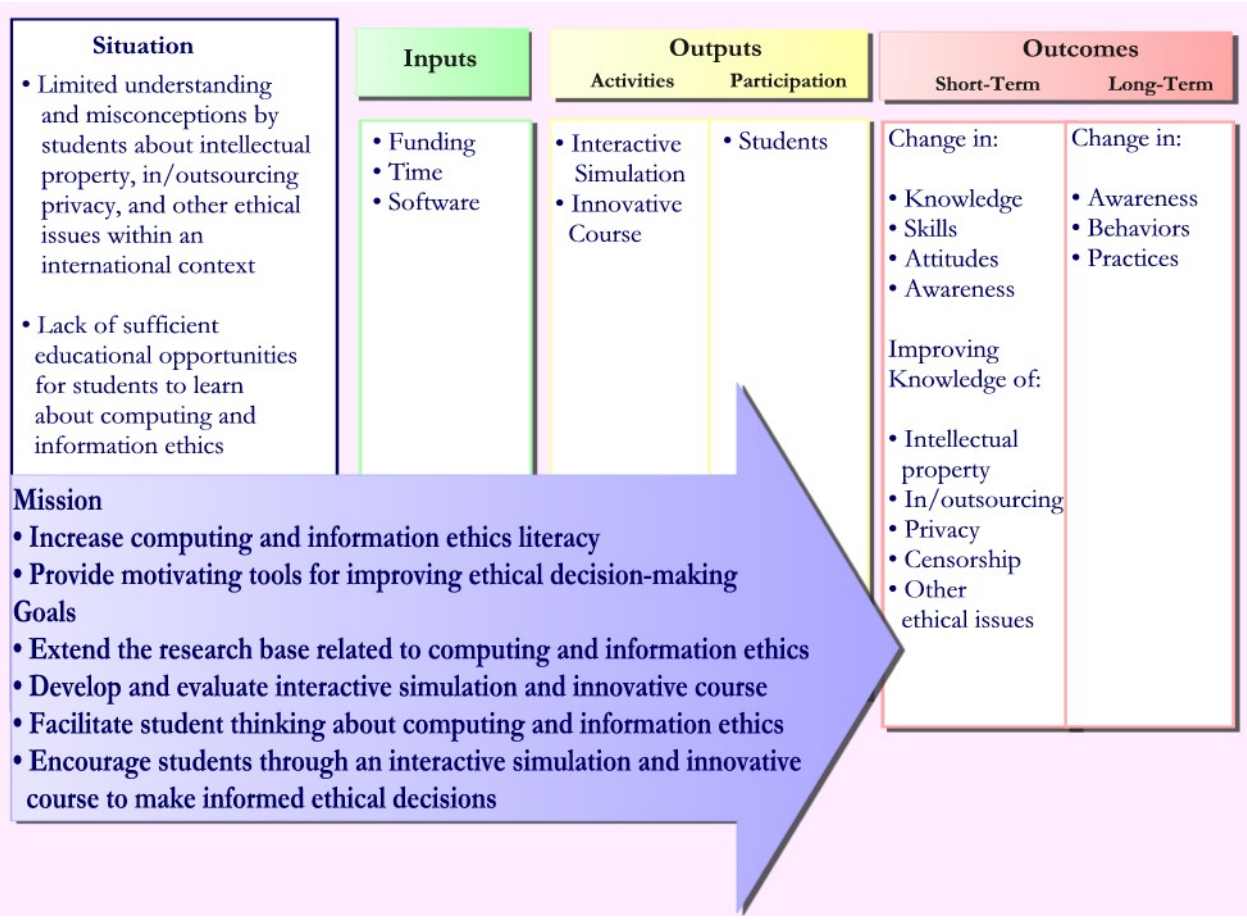

Figure 2: Evaluation Plan for the Simulation and the Course

Focus groups of students in computing and information ethics courses are used to collect data about the course and SIMULATE throughout this study (Stewart et al. 2006). Focus groups of 4-6 students are asked to react to an interface mockup, cases to be used in SIMULATE, and procedures for using SIMULATE in courses. Focus group transcripts are generated by the students and analyzed by the PIs. Insights from focus groups are incorporated into each (re)design of SIMULATE and the course.

Preliminary testing provides additional user input (Dix et al. 1993, Preece et al. 2002, Shneiderman and Plaisant 2004, Virvou and Tsiriga 2000) about the software at various stages of the simulation development, from initial prototypes to the final software. Data collected in the usability laboratory environment include quantitative and qualitative user feedback on various aspects of usability, accessibility, and functionality of the simulation, as well as use of the think-aloud protocol (Ericsson and Simon 1993, Massey and Wallace 1996) that provides data on user experience with the simulation.

In addition, data are collected at the beginning and end of each course (Hashemian and Loui 2005), including questions about the course as a whole; about the usefulness of SIMULATE within the course; about the usefulness of the course readings, class discussions, and supplemental materials; and about overall assessment of the course. Pre- and post-tests and pre- and post-surveys (Self and Ellison 1998, Sindelar et al. 2003) are used to measure the impact of SIMULATE on learning and attitudes.

Data analysis for this study includes quantitative, qualitative, and mixed-method analysis. Quantitative analysis involves the use of appropriate statistical methods, including but not limited to ANOVA, t-tests, and Mann-Whitney U. Qualitative analysis uses grounded theory (Glaser and Strauss 1967, Strauss and Corbin 1998). Mixed-method analysis consists of coding open-ended answers for specific features such as evidence of ethical reasoning or consideration of the values of others, then counting the frequency of different coded answer types, and finally performing appropriate statistical analyses on these counts along with inter-rater reliability, including Cohen's (1960, 1968) Kappa and Perrault and Leigh's (1989) reliability coefficient (Robbins et al. 2004, Robbins 2005).

5.7 Project Management Plan

SIMULATE and the computing and information ethics course in which it is embedded course co-evolve during this three-year study. Table 2 lists the schedule for completing the study.

Semester	Computing & Information Ethics Course	SIMULATE Software
Spring 2008	Teach Information Ethics at Maryland and Marist (Fleischmann & Robbins)	Conduct Focus Groups (Fleischmann & Robbins)
Summer 2008	Refine based on Spring 2008 results (Fleischmann, Robbins, & Wallace)	Develop Alpha Version (Robbins, Fleischmann, & Wallace)
Fall 2008	Teach at Maryland w/ the Alpha Version (Fleischmann)	Test Alpha Version (Fleischmann) Develop Beta Version (Robbins)
Spring 2009	Teach at Maryland w/ the Beta Version (Fleischmann)	Test Beta Version (Fleischmann) Work on Final Version (Robbins)
Summer 2009	Refine to better integrate w/ SIMULATE (Fleischmann, Robbins, & Wallace)	Complete Final Version (Robbins, Fleischmann, & Wallace)
Fall 2009	Teach at Maryland, Marist, & Rensselaer (Fleischmann, Robbins, & Wallace)	Test Final Version (Fleischmann, Robbins, & Wallace)
Spring 2010	Teach at Maryland, Marist, & Rensselaer (Fleischmann, Robbins, & Wallace)	Test Final Version (Fleischmann, Robbins, & Wallace)
Summer 2010	Distribute via Educational Portals (Fleischmann, Robbins, & Wallace)	Distribute via Educational Portals (Fleischmann, Robbins, & Wallace)
Fall 2010	Teach at Other Institutions (Wallace, Fleischmann, & Robbins)	Test at Other Institutions (Wallace, Fleischmann, & Robbins)

Table 2: Schedule for Creating SIMULATE and the Course

5.8 Plan for Dissemination of Results

Research findings are submitted to peer-reviewed journals such as *Communications of the ACM*, *Journal of the American Society for Information Science & Technology*, *MIS Quarterly*, *IEEE Transactions on Systems, Man, and Cybernetics*, *Journal of Information Ethics*, and *Ethics and Information Technology*. Educational findings are submitted to *Computer Science Education*, *The ACM Journal on Education Resources in Computing*, *Journal of Information Technology* Education, and *Journal of Education for Library and Information Science*. Refereed papers and workshops are presented at annual meetings of the American Society for Information Science and Technology, the Association for Information Systems, and the Association for Computing Machinery Special Interest Groups for Computer Science Education and Information Technology Education. The workshops are important for disseminating findings of the study and assisting in recruitment of additional sites for further use and testing of SIMULATE and the course.

The advisory board will also play an important role in dissemination. Advisory board members plan to implement the simulation and the course in their own teaching where possible, and also can encourage their colleagues to use the simulation and the course. The PIs, especially PI Wallace, further disseminate SIMULATE and the course by traveling to other institutions of higher education first to encourage use of SIMULATE and the course and then to guest lecture within similar courses started at other institutions through the dissemination efforts of this study and to observe use of SIMULATE within these different educational settings. As open-source software, SIMULATE can be linked to from a range of sites such as www.onlineethics.org, computingcases.org, www.merlot.org, and sourceforge.net.

6 Intellectual Merit

This study aims to contribute to the computing and information ethics education and ethics education support systems literatures by incrementally and iteratively building, using, and assessing an educational simulation for computing and information ethics and a course built to support repeated and varied use and study of use of the simulation. By so doing, the study demonstrates how students use the simulation when learning about ethics. Specifically, it shows how students can learn about the leading ethical approaches as well as their own values and the values of others, especially including fellow students from other cultures. It also examines the empirical relationships between values, criteria used by students to solve ethical problems, and the decisions these students arrived at when using the simulation. These insights can deepen our understanding of the relationship between ethical problem-solving and cultural values.

Another area of contribution of the study is to extend the research reported in the literature that compare face-to-face and online education by generating new data that explore the impact of geographical co-location versus online context on the effectiveness of using an educational simulation for computing and information ethics. Thus, this study adds an important and currently missing piece to the literature on computing and information ethics education through testing of educational simulation use both face-to-face and online which also has implications for ethics education and educational technology design and use broadly conceived.

A third contribution of the study is to compare use of an educational simulation for computing and information ethics that involves interaction with other people and interaction with software agents. This contribution is accomplished through development of novel software agents that represent established ethical perspectives. The agent version is compared to a version that involves students working in groups. As a result, the study provides valuable data and insights comparing interaction with other people and with software agents. The study also provides valuable data regarding using software agents as virtual characters in simulation games as opposed to as tutors or similar roles. As such, this study can revolutionize research and education within the domain of educational simulations for computing and information ethics and also impact ethics education and educational technology in general.

7 Broader Impacts

The most tangible impact of this study is the development of SIMULATE as documented open-source freeware available to all interested educators and students via the Internet. Not only can SIMULATE be used for teaching computing and information ethics but also, because it is distributed as open-source

software and designed to allow input of user-developed cases, it is easily applied to other domains of ethics education in science and engineering, such as through collaboration with the Maryland Initiative on Research Ethics (see attached letter of support from Dr. Sandra Greer, PI of this funded EESE project).

The second broader impact of this study is the development of an innovative course for computing and information ethics. All resources used to teach this course, including the syllabus, potential case videos, discussion topics, anonymous records of debates, online presentation slides, etc., are distributed via the web portal created as part of this study and through the sites listed above. Thus, the materials are tested in real courses in multiple educational settings broadly available to any interested educators and students across the USA and around the world, as well as to researchers interested in extending the functionality of and further evaluating SIMULATE.

By providing the online simulation and additional educational resources for teaching computing and information ethics, this research aims to better prepare diverse, internationally-focused computing and information professionals. These materials are useful in increasing emphasis on ethics for professional Master's students in computer science and information fields, preparing these students to face ethical issues during their computing- and information-oriented careers in a global economy. It is important to note that this research also provides funding for two doctoral students and two undergraduate students within computing and information programs, and strong efforts are made to recruit students from underrepresented minority groups to serve as members of the research team.

Results from Prior Relevant NSF Support for Kenneth R. Fleischmann: Dissertation Research: Designing from Below: Embedding Knowledges and Values in Educational Simulations (SES-0217996); PI: David J. Hess; Co-PI: Kenneth R. Fleischmann; Period of Funding: 07/15/02 to 06/30/04 (including one year of no-cost extension); Funding Awarded: $7,990.

This study identifies that that values play an important role in the design and use of educational simulations. For example, packaging, promotional materials, and even the interfaces with frog bodies can contain embedded animal advocacy values, through terms such as "frog-friendly software" or an interface that involves building, rather than cutting into, a frog body (Fleischmann 2003). The study also finds that users can indeed become designers, as in the case of biology teachers who become simulation designers (Fleischmann 2006a). Educational simulations also shape and are shaped by educational standards, including the increasing reliance on science and technology standards (Fleischmann in press). This study also identifies online versus face-to-face use and group versus individual use as important factors in educational simulation use, and argues that educational simulations should be designed to take these important factors into consideration (Fleischmann 2005). Overall, this research contributes of a new methodological approach, the boundary objects with agency framework, which can be applied to other problems in computer science and the information field (Fleischmann 2006b). In addition to these five solo-authored peer-reviewed journal articles, the products of this study also include a doctoral dissertation (Fleischmann 2004) and four refereed conference presentations.

Results from Prior Relevant NSF Support for William A. Wallace: ITR: Trust and the Information Consumer: A Graph Theory Approach (IIS-0081219); PI: W.A. Wallace; Co-PI: K. Carley (Carnegie Mellon University), Period of Funding: 09/01/00 to 08/30/04, (including one year of no-cost extension); Funding Awarded: $468,452.

This study involves development of software to implement a meta-graph methodology for constructing consensus graphs from collections of graphs, a virtual experiment to examine computational aspects of the methodology, and a subjective evaluation study to determine the validity of the results in representing consensus knowledge. Another important outcome of this completed project is research training for three graduate students. Results of this completed project include three peer-reviewed journal articles published or in press (Chopra and Wallace 2000, Fleischmann and Wallace 2005, Kelton, Fleischmann, and Wallace in press), two book chapters (Chopra, Mendonça, Rush, and Wallace 2000, Wallace and Fleischmann 2005), a doctoral dissertation (Chopra 2001), and four refereed conference presentations, including three published in proceedings (Chopra and Wallace 2001, 2002, 2003).