Consequences of Computing: A Framework for Teaching

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| http://www.seas.gwu.edu/%7Eimpactcs/images/gw2blk.gif | IntroductionComputer Science has advanced rapidly in the last several decades, and this advance has necessitated the continual revision of the curriculum in an evolving discipline. Not only have new areas of interest been added, but new approaches have influenced the ways we think about established areas in computer science. One of the fundamental changes in computer science in the last decade is the realization that the context in which technology is used must be taken into account in its design, partly because of the ethical implications of its use, and partly because understanding the context of use helps inform and improve the design [6, 30, 37, 48, 58]. This recognition is included as one of the foundational principles in Curricula 1991 [53], and has been a part of curriculum standards for over a decade [1, 11]. Thus, as a part of the natural evolution of a maturing discipline, the social and ethical context of the discipline has been included in its basic undergraduate curriculum.**Why should this be so?** The authors cited above agree in their reasoning for teaching the ethical and social issues in computing. Computing is an enterprise that is neither simply mathematical nor simply practical; it is a mixture of both. Curricula 1991 recognizes this by using a definition of the area that emphasizes the mathematical, scientific, and engineering roots of the discipline. Mathematics helps to determine the most efficient algorithms for any set of inputs, but are not central in solving the issue of how best to display the output of that algorithm to a variety of users. We can quantify the complexity of a procedure, but this quantification by itself does not resolve the need for a judgment of the risk involved in using that procedure in a particular application. We can mathematically describe the state of a machine, but if we want to make claims about its effectiveness in use, we also need to understand the situation in which that machine will be used. Thus the actual practice of computing involves judgments about computers in use, and these judgments require knowledge and skill in the ethical and social context of computing.A concern with computers in use is reinforced by the recognition that most Computer Science majors expect to use the skills they learn as students in jobs in industry. Thus, from their perspective, an emphasis on computers in use is quite practical. It prepares them to use their technical training in the context of the world in which they will be working. Computer scientists in industry regularly face issues that call for professional judgment, and often that judgment cannot be rendered in precise mathematical terms. |

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The conceptual approach integrates, from the perspective of computer science, the complementary disciplines **of philosophical ethics** and **social science**. Based on this integration, the topical areas we recommend concur with those listed in Curricula 1991, but expand on them in terms of both detail and breadth.

It is clear that the study of ethical and social issues in computing is, and should be, interdisciplinary in nature. Ethicists from both philosophy and theology, historians, social analysts, sociologists, anthropologists, and psychologists have all contributed heavily to the research in this area. Instead of suggesting students learn each discipline separately, we suggest that, from the perspective of computer science, every ethical concern is located at a particular level of social analysis. Only an analysis that takes account of at least **three dimensions**--the technical, the social, and the ethical--can adequately represent the issues as they concern computer science in practice. Considering each dimension separately provides some insight, but it is only in their interaction that we can begin to grasp the complexity of the issues.

Although philosophers and ethicists bring their own useful methods and constellations of issues to the study of computing, many of the ethical issues they confront are only made relevant to computer science because computing is both influenced by and influences the social world. The nature of the ethical analysis can differ depending on the particular social agendas or power conflicts at issue. For example, the ethical issue of privacy changes its shape as we look at individual, global, national, and organizational levels of analysis. In addition, different understandings of professional ethical obligation may occur depending upon the particular technology (phone, fax, e-mail, etc.) and the level of social analysis (individual, organizational, cultural, national).

Social scientists also bring a collection of methods and issues that help us frame the problems that face practicing computer scientists. But from the perspective of the computer scientist, these analyses are useful for the purpose of informing practice, and thus ethical considerations of good practice cannot be avoided. Thus, any careful social analysis at a particular level for a particular technology, will likely raise a number of ethical issues (privacy, property, power, risks, etc.).

There are patterns that remain the same across the dimensions (e.g. philosophical issues of the grounding of rights), but their application and relevance to computer science change depending on the context. For this reason, careful attention to the social, technical, and ethical context is required for a good understanding of any issue. It is essential for students to understand the multidimensional nature of the problems computer scientists face as they design and implement systems in the world.

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A careful analysis of any ethical issue will need to specify and examine the ethical issues, the level of social analysis, and the technical aspects of the issue at hand. The

**Figure 1. The intersection of ethical and social analysis**

***(Click on the individual row and column headings to find out more about each topic.)***

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committee's attempt to specify the space defined by these dimensions is summarized in Figure 1. The two dimensions shown in detail are the level of social analysis and the particular ethical issues that arise in technology. A third dimension is indicated, but not specified strictly in the table--the different technologies that each require analysis from some portion of the two-dimensional space. Since the technology changes so rapidly, we felt it would limit the use of the conceptual scheme, and unnecessarily date the approach to attempt to specify this dimension except by example.

Each of the ethical issues represented by a column in the table has been dealt with at great length in both primary and secondary scholarly literature, and in popular and academic venues. Philosophical work done on the concept of property could alone fill several bookshelves. Each of the levels of social analysis represented by the rows of the table also has a literature associated with them that includes thousands of references. Thus, the combination of these two dimensions results in such an overwhelming wealth of research and analysis that it could be difficult to determine where to start.

Fortunately, we have a clear rule to help us determine our starting point. What topics, principles, and skills from this array will be relevant to computer science students at the undergraduate level? Thus, a consideration of the issues that arise for computer professionals, and which are often dealt with in codes of ethics, is both a fundamental and an integral part of any topic covered in the table. Fundamental, in that the approach assumed when addressing these issues should be that of the computing professional and not that of either the philosopher or the social scientist. Integral, because the issues of individual and professional responsibility should be explicitly addressed when dealing with every topic in the space (though for pedagogical purposes, we have included a column with that title). For example, a simple discourse on the nature and history of property rights or on cultural diversity would be out of place unless each were considered from the viewpoint of the computing professional, and unless questions about the practice of the profession in light of these issues were addressed. The methods, insights, and results of philosophers and social scientists should be used in the service of computer science interests, rather than controlling those interests.

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This section is a short explanation of the rows and columns of the charts used in Figures 1 and 2. Any in-depth analysis would require a chapter length treatment for each concept in each dimension. The purpose here is simply to indicate why each of the levels of analysis or ethical issues identified in the chart is important to an analysis of computer technology from the viewpoint of the computer professional.

We would like to be able to argue that the set of ethical issues and social analyses we provide here are a comprehensive taxonomy of the field: that it covers all the important issues, and that any issues will find a place within it and be illuminated by an analysis using the categories we propose. Clearly, we cannot claim this much for a new approach, and only extensive use will determine if the categories or conceptual scheme need to be revised. We can, however, make the claim that this is a reasonably comprehensive and quite useful categorization of the issues in their ethical, social, and technological aspects, and that it provides an organizing framework that has been rare in most approaches to the ethical and social issues in computing.

##### Levels of Social Analysis

A common approach in social analysis is first to determine the level of analysis required for a particular issue and then to apply the tools, literature, and methods appropriate to that level. This is not to suggest that there is a "privileged" level, since many issues must be analyzed at several levels in order to understand them. But it is to suggest that determining the appropriate levels of analysis will help in teaching social and ethical issues in computing. Some issues (e.g. privacy) will profit from analysis at all the levels we propose here. Others, (e.g. whistle blowing) may find some levels less immediately useful. However, we suspect that most issues can profit from a consideration of all the levels of analysis. For example, state and national laws have been considered that would protect whistle blowers, and in addition to individual differences in attitude toward safety risks, there may be cultural differences. Thus, applying a systematic social analysis to the issue of whistle blowing can keep us from thinking only in terms of the individual and professional responsibility of the potential whistle blower.

In this section, we provide a description of each level of analysis, some examples of a few issues that can be profitably analyzed at each level, and some suggestions about how the particular level interacts with the ethical issues represented by the columns in Figure 1.