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Getting Women Wired: New Connections in Art and Technology*

Does computer science in its theory and practice embody discrimination against women, and if so, how does embedded discrimination work itself out in applications to the arts? This essay, guided by this introductory question, will connect concerns of discrimination against women in the field of computer science with issues that arise in the development of theory and application in the emerging electronic computer based arts. Bias against women in computing, I will suggest, occurs in the epistemology or knowledge construction of computer science inherited from the knowledge construction of modern science, works itself out in knowledge distribution and socialization processes, alienates women, ethnic groups, and class groupings, limits access, and skews applications in the arts.

This bias will be examined through 1) a social study and an historical analysis of the domain of modern science and the field of computer science, and 2) an analysis of data collected through survey questionnaires and follow-up interviews that I developed to further locate bias against women in computing and administered during 1994 and 1995 at two major U.S. research institutions with strong concentrations in computer science and arts related areas. These several methods of inquiry combine to search out how the formations of modern science and computer science interact with the arts and gender. The findings will be employed in initial theory building for the emerging electronic arts.

Although this essay will focus on women, including women of minority groups, computing, and the arts (omitting findings concerning minority peoples), an alienation of women also includes men, eliciting an ethical concern of social justice that affects the entire computer science community and communities incorporating computer technologies.

Difficulties for women in computing have been communicated through a variety of major research institutions' reports, in numerous computer science publications, and through published critical studies. To note only a few: the Massachusetts Institute of Technology Electrical Engineering and Computer Science Departmental Reports on Women and Computing in 1983 and 1995, and *Communications of the ACM* issues on "Women and Computing" in 1990 and 1995.[1, 6, 16, 21] These reports confirm what we have come to recognize: *There are biases against women's participation in computing*.

**The complete essay text is located in the SIGGRAPH 96 Visual Proceedings CD-ROM.*

Epistemology and Computer Science

Social study and historical analyses of the knowledge construction of computer science bring to the fore understandings that illuminate deeper problems and beliefs underlying modern science,[20] its off spring, computer science, and discrimination against women. Let me restate briefly a viewpoint that I develop in earlier publications and that builds on the work of physicist Evelyn Fox Keller.[10, 11, 13, 14] A quote from George Simmel initiated Keller's inquiry into gender and science: "The requirements of… correctness in practical judgments and objectivity in theoretical knowledge… belong as it were in their form and their claims to humanity in general, but in their actual historical configuration they are masculine throughout. Supposing that we describe these things, viewed as absolute ideas, by the single word 'objective,' we then find that in the history of our race the equation objective=masculine is a valid one."[11] Simmel's conclusion leads Keller to question: "How is it that the scientific mind can be *seen* ... as both male and disembodied?"[11]

In her early exploration, Keller asserted that modern science is a domain shaped by males, claiming that science is a socially constructed category perpetuating the deeply held *mythology* that holds objectivity, reason, and mind as male, and subjectivity, feeling, and nature as female.[10] This myth has led to the division of emotional and intellectual labour; women residing in the realms of the personal, the emotional, the particular, "whereas science – the province par excellence of the impersonal, the rational, and the general – has been the preserve of men."[10]

This division affects the very terms in which science has been criticized and has led to two notable omissions in most social sciences of science.[10] First, a failure to take serious notice of the fact that the natural sciences, the "hard sciences," have been developed almost entirely by white, middle-class males.[10] Second: an attempt to identify the non-scientific determinants of the development of scientific knowledge, the social studies of science, has ignored factors related to the human psyche; "science is a deeply personal as well as a social activity."[10] Keller came to the conclusion "that perhaps the most important barrier to success for women in science is derived from the pervasive belief in the intrinsic masculinity of scientific thought."[11] The early years of Keller's investigation brought forth two important understandings: she shifted the emphasis of the question of male and female to that of "beliefs" about male and female, that is gender ideology, and second, she concluded that such beliefs could affect science.[11]

Computer science shares the philosophical base of modern science, situated in traditional western philosophy.[4, 9] The shaping of this epistemological ordering began with the ideas of Plato, who supposed a linear, rational, and abstract approach to knowledge, and with further conceptual development by Descartes, Hobbes, Kant, and Whitehead.[4, 13, 14] This epistemological ordering, combined with historic and social understandings that white males developed modern science and the perpetuated myth that men are involved in intellectual labour and women with the realm of the emotional, brought about a continued populating of the domain of modern science by mainly males. The new field of computer science employs the methodology of the "hard" sciences and its Western epistemological ordering to bring comparable rigor in its own knowledge development.[7] Cartesian epis-

temology, situated in this tradition, forms the underpinnings of computer science as we know it. Like the domain of modern science and for the same aforementioned reasons, the field of computer science is populated mostly by males.

This ordering of knowledge, from Plato onward, systematically ignores living contexts.[4] Following in this tradition of Western philosophy, computer science also ignores questions concerning gender ideology, ideas about ethnicity and class, considerations affecting power constructs managing electronic-based information and equipment access, and leads to a skewing of computer-based arts applications.[4]

Survey and Interview Formulations

To further investigate beliefs and deeper problems concerning bias against women in computing arising from the epistemological discussion, survey questionnaires and follow-up interviews were developed to search out bias in more applied settings and were administered at two U.S. research institutions in 1994 and 1995. These instruments build upon and expand existing research .[2, 14, 15, 16, 18, 19, 20]

The mainly qualitative survey instrument was distributed in one institution to 154 graduate and 282 undergraduate students in its computer science department and in a related arts research center with a 30% return. The graduate survey was comprised of 1) demographics, 2) five questions searching out obstacles to computing, 3) nine questions investigating salient personal, social, and control beliefs about women in the field of computing,[3] and 4) a question canvassing additional obstacles to computing that the survey failed to address. The undergraduate survey contained an additional quantitative component seeking statistical data.

The single person interview administered to graduate students, academic administrative faculty, faculty members, personnel, and artists, from the computer science departments and computer-based art research centers at both institutions, consisted of three questions that searched out more thoroughly the basic premises of the survey. The interviewing resulted in 21 transcribed interviews.

Survey and Interview Findings

What do the findings offer for a deeper understanding about the knowledge construction of computer science and bias against women? We will focus specifically on findings from the third survey component, searching out salient personal, social, and control beliefs about women in computing.

Personal Beliefs About Women's Participation in Computing in Relation to Knowledge Construction

Looking at personal beliefs about the personal consequences for women in computing, a multiplicity of disadvantages were noted. From the vantage point of knowledge construction, females suffer intellectual intimidation from "the old boys' network", which often stereotypes women as illogical, leaving male instructors with a sense that they are unable to deal with women's apparently differing approaches to knowledge. This furthers a perception that males are given an assumed edge in computing with regard to knowledge comprehension and knowledge development. Some respondents view women as more successful in computing, as they employ a more logical approach; however, this supposition conforms to the existing dominant approach to knowledge acquisition. Other respondents put forward the "critical mass concept," – an understanding that having a larger number of competent women in the field will reduce the amount of knowledge-base intimidation and discrimination.

Interviewee Professor Douglas Kerr of the Ohio State University Computer and Information Science Department noted that a central difficulty for first-year female undergraduate computer science majors is that they do not possess the prior computing knowledge, accompanied by the prior computing experience, of their male counterparts who have been "hacking" on the computer often from the age of four years.[12] This circumstance I label the "time-loss factor," pointing to the gap between what males often acquire at young ages, and what becomes a "time-loss factor" for females who develop computing knowledge and computing experience at later ages. The male working on the computer from the age of four years, becoming sophisticated with the rational and hierarchical development of computing and participating in the male construct already in place, matures in a space that he finds comfortable. This leads to a world of computing that tends to welcome the male, to undermine and distance the female, and by the time the two seek out majors in computer science, the young female believes she can no longer compete. Although her intellectual gifts appear to be equivalent to those of her male counterpart, she does not possess his prior-knowledge, prior experience base in computing.

Control Beliefs About Women's Participation in Computing in Relation to Knowledge Construction

The category of control beliefs (beliefs about factors that facilitate and obstruct women engaging in computing) points to many similar problems noted under personal beliefs. Additional findings elaborate particular difficulties and exclusions for females from the vantage point of knowledge construction.

A major difficulty is knowledge-base intimidation; women in computing comprehend less, develop less, and often believe themselves to be capable of less. This understanding is advanced through educational systems that facilitate the participation of males in math and science and discourage females. Both male and female respondents at all levels of computer science higher education continually raise the difficulty of sexual harassment in relation to knowledge acquisition and socialization processes.

A second control belief frustrating women's participation is a sense of exclusion. Studies in educational computing research consistently illuminate the predicament of a lack of computing in elementary and secondary schooling, noting attempts to continually improve levels of computing education. And those who generally benefit from the availability of existing computer education are the males. Again, a knowledge-base "time loss factor" occurs in relation to the female. Along with preferred male development in computing in primary and secondary education comes the understanding that computing is

becoming more logical, again reiterating the conception of Western science that underlies computer science. These exclusions tend to discourage intelligent and capable women who wish seriously to pursue academic and professional careers in computing.

There appears on the forefront, however, factors encouraging women's participation in computing. Changes that offer reassurance *for women* include an increase in the number of female academic role models at all levels of math and science education, better computer science education at all levels of education, and stronger support in educational contexts for younger girls at the primary and secondary levels of math and science.

Socialization and Computer Science

An analysis of socialization and computer science is assisted by Keller's social study of modern science. Keller examines the social structuring ramifications of the perpetuated fiction of the male possessing objectivity, reason, and mind, with the female exhibiting a stronger affinity to subjectivity, feeling, and nature. This artificial gender partition has led to perceptions that continue to manifest themselves in the worlds of the sciences and computing.[18] Our examination of the social beliefs about women in computing will focus particularly on social control beliefs.

Control Beliefs About Women's Social Participation in Computing

Although the findings note some obvious sociological concerns such as sexual harassment and male chauvinism, the social control belief findings repeat the same factors noted in the earlier section about control beliefs and knowledge construction. This finding is particularly important because it points out that the knowledge construction of computer science seemingly more fully discourages females than do the sociological factors.

The data suggest that both knowledge construction and socialization are major intertwined problems, and point to a primary concern for a restructuring of knowledge construction linked with socialization. To summarize, the findings call for strategies within all levels of computer science education and the computing industry to alter the "time-loss factor," to search out alternative approaches to computing along with those based on western logic, and to build the "critical mass factor," which includes both female leaders and mentors to complement male leaders and mentors.

In contrast to the clear analysis of control beliefs pointing to dissuading factors related directly to knowledge construction, this same category had much to offer in findings that encourage women's participation in computing. Although the findings brought forward social-based suggestions, they overwhelmingly reinforced the understanding that the most encouraging factors come from changes taking place in a linking of knowledge development with socialization in computer science education: computing in elementary school with girls swayed by parents and teachers to participate, more encouragement from parents and educators from elementary levels upward for girls to take part in math and science, and more female teachers and professors in the math, science, and computer science. Encouraging social control beliefs include the breaking of gender stereotypes, parents encouraging their daughters to enter computer-based careers, and awareness by engineering and computer professionals concerning social conditioning and structuring in their professions. Young girls encouraged by parents, the education enterprise, and by industry, and with broader choices in computer hardware and software, could establish a comfortable presence in a more inclusive world of computing and develop the computing prior-knowledge and computing prior-experience expertise that begins to diminish the "time-loss factor."

New Connections in Art and Technology

If there exists, as suggested, discrimination against women in the theory and practice of computer science, what does this have to do specifically with developing theory and application in the emerging electronic arts? Applications of developing electronic technologies to the arts embody the underlying epistemological structure of computer science that forms the technologies. The application of a particular electronic technology is not an act of neutrality, for it embraces the epistemological structure of that technology[20] and passes on implanted discrimination.

Looking particularly to applications of electronic technologies in the arts, let me mention three contemporary challenges raised by this hidden discrimination. First, the electronic arts suffer from a lack of validity because there exists little theory shaping the contexts and discourses about the electronic arts. As Simon Penny of Carnegie Mellon University points out, our "[s]ystems of communication and structures of power have changed yet the worldviews and critical systems that operate in many of our institutions are pre-electronic, often pre-industrial."[17] Traditional art historical methodologies are a case in point; they fail to address the emerging electronic arts. We face the challenge of developing theory that is ethical in its forming and embraces understandings of the theory and practice of computer science; understandings of the arts including aesthetics, history, criticism, and production; combined with our daily living contexts involving power constructs managing electronic-based information and equipment access, and including gender, class, and ethnic concerns.

Second, in our theory building we can take account of analyses of biases against women in computing and address these living problems. Current computer science must be reshaped if arts applications are to move beyond their restrictive and imposed parameters.

Third, we live in a world shaped by information technologies, and the shaping of our culture by these technologies begs for theoretical direction. A shaping of theory that adequately informs the arts and an emerging digitally shaped culture calls for a convergence of separate discourses in the arts: a joining of 1) the evolution of the electronic-based arts and 2) radical theories of representation that have dominated recent arts discourse. Timothy Druckrey astutely points out that "theories of interactivity must be joined with theories of discourse."[5] The changes I am suggesting for the theory and practice of computer science and for theoretical forming in the arts call for a communal effort by those involved in the reworking of theory in these particular disciplines and fields and in their interdisciplinary crossings. We stand at a point where emerging theory can connect the partitioned concerns of arts discourse, electronic technologies, and our everyday living contexts.

In conclusion, let us return to the question that initiated our discussion. Does computer science in its theory and practice embody discrimination against women, and if so, how does embedded discrimination work itself out in arts applications? Social study and historical analysis along with survey and interview data strongly suggest that there exists discrimination against women in computer science and that it is passed on to arts applications. By addressing specific sources of gender discrimination in the theory and practice of computer science linked to developing theory in the emerging electronic arts, we can begin to get women wired in ways that include, rather than exclude, and create new traditions that place human beings and our communal well-being in the foreground of ongoing developments in electronic computer-based technologies.

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