An ACM-W Literature Review
on Women in Computing

Denise Gürer
ACM-W Co-Chair
EMD Consulting
Scotts Valley, California 95066 USA
<gurerd@acm.org>

Tracy Camp
ACM-W Co-Chair
Colorado School of Mines
Golden, Colorado 80401 USA
<tcamp@mines.edu>

Introduction

The pipeline shrinkage problem for women in computer science is a well-known and documented phenomenon where the ratio of women to men involved in computing shrinks dramatically from early student years to working years [19, 22, 23, 32, 42, 93, 112], also see this issue [24]. During the last decade, considerable research ensued to understand the reasons behind the existence of the shrinking pipeline and in some cases to take action to increase the numbers of women in computing. Through the work of a National Science Foundation funded project [56], ACM's Committee on Women in Computing (ACM-W) has taken a first step towards pulling this research together. A large number of articles was gathered and processed on the topic of women in computing and the shrinking pipeline. The committee created a publicly available online database to organize the references of this body of work by topic, author, and reference information. The database, constantly being updated, is accessible through ACM-W's website <http://www.acm.org/women>. A final report is also available via the ACM-W website which covers current statistics on women in computing, summaries of the literature in the database, and a set of recommendations.

The following discussion is a brief synopsis of a subset of the literature review as of August 2001. In addition, you can find statistics on women in computing and recommendations throughout this special issue.

Literature Review Categories

It is imperative that we encourage and retain more women in computer science (CS), see this issue [7, 15, 46, 66, 74]. This gives rise to the questions: Why are the numbers going down? and, How can we reverse this trend? The ACM-W database provides a starting point to compiling published work on women in computing issues. The information contained in the database can be divided into 12 areas: early in the pipeline, attitudes, computer experience, computer games, mentoring and role models, self-confidence, comput-

ing environments, societal influences, teacher and family encouragement, all-female environment, graduate school, and balancing work and family. The following is a very brief description of the findings for each identified category.

Early in the Pipeline

Girls lose interest in computer science early on [17], also see this issue [64]. While boys tend to "jump in" and explore computers without explicit permission, girls wait to be told what to do and often ask permission to explore the computer on their own [13]. Often times boys also tend to monopolize the instructor's time, leaving the girls to try and figure things out on their own [61]. This imbalance can frustrate young girls, which in turn leaves them with a dislike of computing and causes boys and girls both to think that computing is a male domain. This attitude changes only when both sexes see, on a repeated basis, that their female classmates as well as their female instructors can successfully use a computer. It is important as early as preschool to emphasize to children that computing is for both genders [39, 78, 107].

Equal access to computers is another issue. In many cases, boys dominate a computing lab and the girls do not get the same exposure to computers. Adequate amounts of individual computing time will ensure all students obtain the computing skills needed in the future [59]. In a computing environment, boys typically tend to take on the role of hosts, where they feel as though they must completely understand the associated material; girls act as guests, where they feel they can have a basic understanding of the material but can make mistakes in order to learn more [34]. Thus, boys tend to take over in an attempt to prove their knowledge while the girls feel comfortable in sitting back, watching the boys, and admitting that they are less knowledgeable than their male counterparts. As a result, girls are voluntarily giving up their computing time and unknowingly allowing the boys to gain more experience. It is important to note that given the opportunity to gain computing experience, girls are capable of evenly competing with boys [5, 89]. Thus, it is vital that

girls have equal access and gain as much computing experience as they can during their early school years.

Attitudes

Positive attitudes towards computer science can greatly influence the success of a student and whether she continues in computer science. In general, attitudes towards computers and their uses differ along gender lines where more boys are positive and more girls are negative towards computing [21]. However, it is not until later years that gender differences become pronounced. Most preschool and elementary level students seem to have positive attitudes towards computers. In addition, the majority of studies have shown that those spending more time with computers have a more positive view [79, 102]. Thus, it is crucial that we give children at a young age equal exposure to computers and they have positive experiences to carry through to their later years [13, 39, 77].

One approach for middle and high school students is to expose them to female CS instructors. Even those girls with little or no computing experience perform surprisingly well and report positive attitudes when they are in the presence of a female instructor [28].

Computer Experience

As a person gains experience with a computer their level of confidence in using computers increases and they become more comfortable with the common jargon and tools of CS [101]. Studies show that large numbers of women students are entering first level computing courses at universities with less experience than their male colleagues [91, 94, 100] causing many to not even consider computer science as a possible major. Compounding the negative effects that a lack of computing experience and skills may have on female students, are the effects of course prerequisites. Quite a few first year computing courses assume a certain level of knowledge that, through no fault of their own, many female students have not yet obtained [14]. It cannot be emphasized enough that this is due to a lack of pre-course skills or experience, and not a lack of ability or interest. Thus, educators should focus their attention on introducing female students to computer science studies and jargon as soon as possible [25, 29, 48].

Computer Games

Computer games are usually children's first experience with computers, which plays a large role in determining their future interest and enjoyment in using computers [84, 106]. Unfortunately, the majority of computer games target the boy market [6, 10, 44, 49, 50], also see this issue [33, 72], and software designers exhibit gender biases [62], also see this issue [63]. These boy-based games consist of repetitive shooting, violent graphics, and loud noises − most of which do not appeal to girls. Even worse, the few women incorporated into video game covers are usually in submissive roles portraying a fearful and usually well-endowed creature, while the males stand in dominant poses [27, 87]. Typically,

girls do not enjoy these negative images and the repetition of the music and game activities. Girls tend to prefer games that encourage collaboration with other players and involve storylines and character development where female characters are powerful and not waiting to be rescued by their prince [9, 47, 51, 65, 71]. Furthermore, in video arcades children are often subject to aggressive behaviors such as shouting and swearing, which is offensive and intimidating to young girls [73, 84]. Also, see this issue [68]. All of these boy-dominated characteristics turn girls off from using computers at an early age.

Mentoring and Role Models

Research shows that mentoring programs help the recruiting and retention rates of women in computer science [109]. One type of mentoring utilizes the Internet in a form of tele-mentoring [11, 12, 26, 83, 85, 95]. Summer research projects are another way to promote and retain women in computer science such as PipeLINK [117] and the Distributed Mentor Project [29]. You can find discussions of what it takes for a good mentor-mentee relationship in [29, 86, 99], and in this issue [114]. Not surprisingly, studies indicate that women best mentor women and girls [40, and in this issue 96].

Another related method to increase the percentage of women in computing is through role models [18]. Girls can interact with women computer scientists online, in person, or through biographies [90, 97, 98, 113], public talks, or the history of computer science [54, 55, 103], and in this issue [53, 57, 75].

Self-Confidence

A lack of self-confidence is a driving force on all parts of the pipeline that causes many women to leave or even not to enter the field of computer science [2, also see this issue 96]. Studies have shown that self-confidence hinges on four different components: performance and accomplishments, observing and learning from others, freedom from anxiety concerning work and conduct in a particular field, and persuasion and support from others [3, 4]. We can trace, in part, reasons for decreases in student self-confidence back to the actions of many professors. Female and male professors both tend to call on their male students more often; they ask them questions that are more challenging and interact with them more [76]. The problem is exacerbated when combined with sexist attitudes from male students. For example, many male students tend to haze women when they are not familiar with a certain computerized concepts by insinuating that such basic ideas should be well known to all computer science majors [36, 37, 82], also see this issue [38]. Often times women are at the same level or higher than their male classmates in terms of computer knowledge but still refuse to give themselves credit for such admirable accomplishments, whereas men have no trouble crediting themselves for their achievements [35, 89].

Computing Environments

Some men tend to encourage the creation of uncomfortable and even hostile environments for women. Males may take over the computer lab, profess their unwavering knowledge of computers, and make fun of others when they make mistakes. The situation worsens when men tell jokes comparing women to computers and display pictures of naked women in their offices or on their computer screens. Although this may be considered typical behavior from many men and is not meant to turn women away, most females tend to feel uncomfortable when forced into these environments [60, 67, 69, 80, 82, 84, 104, 118], also see this issue [38, 105]. Fortunately, many school and university computing labs have become aware of these problems and have taken steps to alleviate this problem.

Another factor in the workplace is communication styles often times differ between men and women. Society has socially conditioned most men to interrupt and insert their opinion in a meeting, while women will wait for an opening in the conversation, which often never happens. Women also find it difficult to have their opinions and input heard. In many cases, a male colleague repeats a woman's idea and then we view the idea as his [110, 111]. This is usually an unintentional act on the male colleague and is more of a difference in communication styles. It is important for managers and team leaders to understand these dynamics and give everyone their fair say and credit when due.

Societal Influences

Society has a profound impact on young girls' images of themselves and computer science. Unfortunately, most of the images of computer science are negative and imply that computing is for nerds (i.e., uncool) or men only [81]. Social environments and parents teach our children how to act like a boy or a girl, even though the physical development of all children is about the same until adolescence. At the point of adolescence, peer pressure is at its highest and is the cause for many talented young girls to lose all interest in science and technology, especially computers. Parents need to assure their daughters that they can be "girly" and still succeed in technological fields by introducing them to all forms of technology, including computers [88].

Media has a strong influence on girls' impressions of computer science. Often times archaic ideas are reinforced such as the idea that boys should be granted access to computers, both at home and at school, before girls because they need to prepare for their engineering careers [70]. Most computing magazines portray only men and young boys as being avid computer users [84, 108]. In addition, the perception is perpetuated that CS careers require longer hours and limit more personal time (e.g., time for family) than other demanding careers. Professions such as medical doctors or lawyers (for example) require long hours but we do not see it as devoid of a personal life for women.

Teacher and Family Encouragement

Typically, classrooms that do not make an effort to provide a gender-neutral atmosphere actually end up promoting a male-oriented domain. With a few exceptions, male math teachers provide instruction for computing courses [30] and instructors of both sexes tend to devote more time to their more demanding male students [61]. This automatically starts the process of creating a male-dominated environment that female enrollees have to overcome.

Children can also be exposed to gender bias in their homes. Unfortunately, some parents unintentionally provide obstacles for their own daughters and through subtle biases provide more support for their male children. For example, the majority of "family" computers are typically set up in the son's bedroom [20]. Mothers also play a very important role in their daughter's perception of technology. For example, if a technically challenged mother presents herself with a fearless attitude when manipulating computers and other technical devices, her daughter will mimic that same attitude [1, 60].

In general, girls lack self-esteem and without self-confidence, it is almost impossible to break new ground and experience new things [52]. It is imperative that teachers and parents take every opportunity available to recognize young girls for their accomplishments and encourage them to take risks and accept challenges.

All-Female Environment

Environments that only allow female students can produce women with higher levels of confidence in math, science, and engineering. This in turn translates into career success and helps to increase the pipeline for women in CS [28, also see this issue 116]. One effect of all-female institutions is that female students no longer have to contend with the intimidating perception that males are better in subjects such as math and science and they do not have to compete with males in speaking up in classes or discussions [92]. Having an all-female classroom allows women's voices to be heard and many women to overcome their reluctance to participate in the classroom. There are other methods to provide all female environments such as small all-female clubs or all-female classes in a co-ed teaching institution [115]. In educational and industrial environments, all-female gatherings such as workshops, seminars, or lunches can also help, see this issue [41, 43, 45].

Graduate School

The pipeline shrinks dramatically from undergraduate to graduate school, see this issue [31]. Encouraging female undergraduate students to apply to a computer science program at the graduate level is very difficult [8]. First, the majority of prospective, female candidates drop out of computer science before they obtain an undergraduate degree, thus making it difficult to seek out qualified individuals. Second, those who are qualified are usually tired of coping with the typical non-women-friendly computer science environment and vehemently decline the offer. In addition, those few who consider continuing their education rarely understand and are unprepared for how graduate school environ-

ments differ from the undergraduate lifestyle with which they are familiar. This may cause them to drop out in their first year of graduate study [29]. For example, undergraduates are encouraged to be good students by accepting a task, completing it well, and then receiving a reward from an authority figure. In stark contrast, behavior in graduate school is expected to be strategic, independent, and void of interpersonal support [35]. Females are often criticized for seeking assistance at advanced levels of education, which further discourages them.

Balancing Work and Family

Working mothers in CS-related positions have a difficult time in today's work environments, especially in the first few years of their child's life when the mother is likely to be breastfeeding. Most managers and companies do not understand the necessity of nursing and do not support it, and nursing moms are often the subject of cow or "moo" jokes [16]. Working mothers also need assistance with childcare, flexible hours, and telecommuting options. Fortunately, many computer science jobs lend themselves to telecommuting since all that is required is a computer and a good Internet connection for work at home. Flexible hours are especially needed in academia where the time a woman is seeking tenure is also the time she is contemplating having children [35]. Since schools are often ill equipped to deal with pregnancy, temporary leaves of absence are commonly encouraged to become permanent. Even when women focus completely on their career and opt not to have children, they are often treated as though their commitment is not strong enough [58]. However, studies show that women are capable of handling both a family and a career if they so desire [104].

Conclusion

The loss of women in computer science is a complex and multi-faceted problem. Many issues combine to provide a powerful force that keeps women away from computer science. It is important to realize that there is no magic pill. A single program or focus will not solve this problem and it will not simply fix itself in time. It is also important to realize that in many cases men and women alike discriminate against female computer scientists in subtle ways that the perpetrators themselves may not even recognize, see this issue [96]. Even when considered trivial, encountering such acts on a constant basis may be more harmful than a few overt incidents since they add up to a feeling of constant harassment. What makes it even more difficult is women feel they cannot complain about these subtle forms of discrimination because people will see them as overly sensitive or as not being a team player.

Fortunately, there has been considerable research on why women are leaving computer science or not even entering the field. Much of this research appears in the ACM-W database. Thus, we know how to begin to stop the loss and perhaps reverse the trend through aggressive and proactive measures. You can find specific recommendations through-

out this special issue. However, it is clear that in general we need to provide more women friendly work and learning environments, engage girls in computing as early as possible, provide the support that women (and parents) need for family responsibilities, educate parents and teachers on gender issues, and actively promote capable women into higher positions and promote their work.

References
[1] Adelson, R. "Daring-Do for Digital Daughters," 1996, http://www.awc-hq.org/livewire/199609.html (accessed March 14, 2002).
[2] Alper, J. "The Pipeline is Leaking Women All the Way Along," *Science*, 260, pp. 409-411, 1993.
[3] Ambrose, S., Dunkle, K., Lazarus, B., Nair, I., and Harkus, D. *Journeys of Women in Science and Engineering: No Universal Constants.* Temple University Press: Philadelphia, Pennsylvania, 1997.
[4] Ambrose, S., Lazarus, B., & Nair, I. "No Universal Constants: Journeys of Women in Engineering and Computer Science," *Journal of Engineering Education*, 87(4), pp. 363 – 368, 1998.
[5] Anderson, R. "Females Surpass Males in Computer Problem Solving: Findings from the Minnesota Computer Literacy Assessment," *Journal of Educational Computing Research*, 3(1), pp. 39-51, 1987.
[6] Angwin, J. "Software Features Boys, Clothes, Barbie," *San Francisco Chronicle*, pp. B1 and B4, August 1, 1997.
[7] Balcita, A., Carver, D., & Soffa, M.L. "Shortchanging the Future of Information Technology: The Untapped Resource," *inroads (SIGCSE Bulletin)*, 34(2), 2002.
[8] Bana, S. & Hassoun, S. "Improving the Graduate School Environment for Women in Computer Science," *Birds of a Feather Session at Grace Hopper Celebration 1997*, http://www.cs.washington.edu/homes/soha/GH/list.html (accessed March 14, 2002).
[9] BBC News "Education Software Sex Bias 'Puts Girls Off'," *BBC Online Network* October 26, 1998, http://news.bbc.co.uk/hi/english/education/newsid_200000/200286.stm (accessed March 14, 2002).
[10] Beato, G. "Computer Games for Girls is No Longer an Oxymoron," *Wired*, pp. 101-106, April, 1997.
[11] Bennett, D. "Providing Role Models Online," *Electronic Learning*, pp. 50–51, March/April, 1997.
[12] Bennett, D., Hupert, N., Tsikalas, K., & Meade, T. "Telementoring: Designing On-Line Mentoring Environments for High School Women in Science and Technical Courses," in *Proceedings of the Joint National Conference on Women in Engineering Program Advocates Network and the National Association of Minority Engineering Program Administrators*, Washington, D.C., 1997.
[13] Bernhard, J. "Gender-Related Attitudes and the Development

of Computer Skills: A Preschool Intervention," *The Alberta Journal of Educational Research*, 38(3), pp. 177-188, September, 1992.

[14] Berstein, D. "The University of Wisconsin Women and Science Project: Is Computer Science different from Other Sciences? Or iIs Teaching Computer Science Different From Teaching Other Sciences?" *Gates*, 4(1), pp. 32-37, 1997.

[15] Borg, A. "Computing, Democracy, Education, and the Future," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[16] Brady, D. "Give Nursing Moms a Break at the Office," *Business Week*, August 6, p. 70, 2001.

[17] Broihier, M., Fleetwood, C., & Krendl, K. "Children and Computers: Do Sex-Related Differences Persist?" In *Journal of Communication*, 39(3), pp. 85-93, 1989.

[18] Brunner, C. & Bennett, D. *Gender and Technology*, Education Development Center/Center for Children and Technology, New York, New York, 1997.

[19] Bryant, R.E. & Irwin M.J. "1999-2000 Taulbee Survey: Current and Future Ph.D. Output will not Satisfy Demand for Faculty," *Computing Research News*, pp. 5-11, March 2001, http://www.cra.org/statistics/ (accessed March 14, 2002).

[20] Brzowsky, B. "Are Girls Being Shortchanged," *Parade*, February 8, 1998, http://www.crpc.rice.edu/CRPC/newsArchive/parade_2_8_98.html (accessed March 14, 2002).

[21] Bulkeley, W. "Gender Affects How User Sees the Computer," *Wall Street Journal*, pp. B1, B5, March 16, 1994.

[22] Camp, T., Miller, K., & Davies, V. "The Incredible Shrinking Pipeline Unlikely to Reverse," 1999, http://www.mines.edu/fs_home/tcamp/new-study/new-study.html (accessed March 14, 2002).

[23] Camp, T. "Women in Computer Science: Reversing the Trend," *Syllabus Magazine*, August, 2001, http://www.syllabus.com/syllabusmagazine/magazine.asp?month=8&year=2001 (accessed March 14, 2002).

[24] Camp, T. "The Incredible Shrinking Pipeline," *Inroads (SIGCSE Bulletin)*, 34(2), 2002, Reprinted from *Communications of the ACM*, 40(10), pp. 103-110, 1997.

[25] Carlstead, S. "Getting Women Involved," *ACM Crossroads*, 3(2), Winter 1996 http://www.acm.org/crossroads/xrds3-2/road.html (accessed March 14, 2002).

[26] CCT. *Center for Children's Technology: Notes*, 4(1), Education Development Center: New York, New York, 1996.

[27] Chaika, M. "Computer Game Marketing Bias," *ACM Crossroads*, 3(2), Winter 1996, www.acm.org/crossroads/xrds3-2/girlgame.html (accessed March 14, 2002).

[28] Corston, R. & Colman, A. "Gender and Social Facilitation Effects on Computer Competence and Attitudes toward Computers," *Journal of Educational Computing Research*, 14(2), pp. 171-183, 1996.

[29] CRA-DMP "Third Party Evaluation of the CRA Distributed Mentor Project: Year 1," *CRA-DMP Evaluation Report #1*", 1996, http://www.cs.wisc.edu/~condon/mentor/third.html (accessed March 14, 2002).

[30] Culley, L. "Option Choice and Careers Guidance: Gender and Computing in Secondary Schools," *British Journal of Guidance and Counseling*, 16(1), pp. 73-82, 1988.

[31] Cuny, J. & Aspray, W. "Recruitment and Retention of Women Graduates in Computer Science and Engineering," *inroads (SIGCSE Bulletin)*, 34(2), 2002, Results of a Workshop Organized by the Computing Research Association Committee on the Status of Women in Computing Research, June 20-21, 2000, http://www.cra.org/main/cra.pubs.html

(accessed March 14, 2002).

[32] Davies, V. & Camp, T. "Where Have Women Gone and Will They be Returning?" *The CPSR Newsletter*, 18(1), Winter 2000, http://www.cpsr.org/publications/newsletters/issues/2000/Winter2000/index.html (accessed March 14, 2002).

[33] Duplantis, W., MacGregor, E., Klawe, M., & Ng, M. "Virtual Family: An Approach to Introducing Java Programming," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[34] Elkjaer, B. "Girls and Information Technology in Denmark - An Account of a Socially Constructed Problem," *Gender and Education*, 4(1/2), pp. 25-40, 1992.

[35] Eskowitz, H., Kemelgor, C., Neuschatz, M., & Uzzi, B. "Barriers to Women in Academic Science and Engineering," In Pearson W.J. and Fechter, I. (Eds.) *Who Will Do Science? Educating the Next Generation*. Johns Hopkins University Press: Baltimore, 1994. http://www.ai.mit.edu/people/ellens/Gender/EKNU.html (accessed March 14, 2002).

[36] Fisher, A., Margolis, J., & Miller, F. "Undergraduate Women in Computer Science: Experience, Motivation and Culture," *SIGCSE*, 29(1), pp. 106-110, 1997.

[37] Fisher, A., Margolis, J., & Miller F. "The Nexus of Confidence and Interest," working paper of the Carnegie Mellon Project on Gender and Computer Science, http://www.cs.cmu.edu/~gendergap/confidence.html (accessed March 14, 2002).

[38] Fisher, A. & Margolis, J. "Unlocking the Clubhouse: The Carnegie Mellon Experience," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[39] Fletcher-Flinn, C. & Suddendorf, T. "Computer Attitudes, Gender and Exploratory Behavior: A Developmental Study," *Journal of Educational Computing Research*, 15(4), pp. 369-392, 1996.

[40] Fossum, T. & Haller, S. "Retaining Women in CS with Accessible Role Models," *SIGCSE*, 30(1), pp. 73-76, 1998.

[41] Francioni, J. "A Conference's Impact on Undergraduate Female Students," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[42] Freeman, P. & Aspray, W. "The Supply of Information Technology Workers in the United States," *Computing Research Association Report*, 1999, http://www.cra.org/reports/wits/cra.wits.html (accessed March 14, 2002).

[43] Frieze, C. & Blum, L. "Building an Effective Computer Science 1 Student Organization: The Carnegie Mellon Women@SCS Action Plan," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[44] Fryer, B. "Games for Girls in a Gameboy World," *Working Woman*, p. 11, December, 1994.

[45] Gabbert, P. & Meeker, P. "Support Communities for Women in Computing," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[46] Galpin, V. "Women in Computing Around the World," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[47] Gillen, M. "Game Makers Finally Targeting Girls," *Billboard*, 106(23), pp. 88-90, June 4, 1994.

[48] Girl Scouts "Jargon on the Internet," 1998-2002, http://www.girlscouts.org/girls/LINKS/jargonon.htm (accessed March 14, 2002).

[49] Gorriz, C. & Medina, C. "Computer Games for Girls: An Untapped Market," *SRI Consulting*, Menlo Park, CA, 1997.

[50] Gorriz, C. & Medina, C. "Engaging Girls with Computers Through Software Games," *Communications of the ACM*, 43(1), pp. 42-49, 2000.

[51] Graves, D. & Klawe, M. "Supporting Learners in a Remote Computer-Supported Collaborative Learning Environment: The Importance of Task and Communication," *Proceedings of*

Computer Support for Collaborative Learning (CSCL), Toronto, 1999.

[52] Graves, J. "What Makes a Woman Successful?" *Knowledge Share LLC*, 1997, http://www.superkids.com/aweb/pages/features/girls/jg1.shtml (accessed March 14, 2002).

[53] Gürer, D. "Pioneering Women in Computer Science," *inroads (SIGCSE Bulletin)*, 34(2), 2002, Reprinted from *Communications of the ACM*, 38(1), pp. 45-54, 1995.

[54] Gürer, D. "Women's Contributions to Early Computing at the National Bureau of Standards," *IEEE Annals of the History of Computing*, 18(3), pp. 29-35, 1996.

[55] Gürer, D. "The History of Computer Science: A Great Place to Find Role Models," *Computing Research Association Newsletter*, Fall 1998, http://www.cra.org/CRN/online.html (accessed March 14, 2002).

[56] Gürer, D. & Camp, T. *Investigating the Incredible Shrinking Pipeline for Women in Computer Science*, Final Report NSF 9812016, 2001. http://www.acm.org/women/ (accessed March 14, 2002).

[57] Gürer, D. "Women in Computing History," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[58] Hassoun, S. & Soha, B. "Improving the Graduate School Environment for Women in Computer Science," *Birds of a Feather Session at the Grace Hopper Celebration on Women in Computing 1997*, http://www.cs.washington.edu/homes/soha/GH/list.html (accessed March 14, 2002).

[59] Hearne, J.D., & Martin, B. "Computer Equity in Education," *Educational Technology*, pp. 47-51, September, 1989.

[60] Huang, A. Ring, A., Toich, S. & Torres, T. Special Issue: The Effect of Computers on the Gender Gap in Education," *Gender Relations in Educational Applications of Technology (GREAT)*, 1(1), March 16, 1998, http://www-cse.stanford.edu/classes/cs201/Projects/gender-gap-in-education/index.htm (accessed March 14, 2002).

[61] Huber, B. & Scaglion, R. "Gender Differences in Computer Education: A Costa Rican Case Study," *Journal of Educational Computing Research*, 13(3), pp. 271-304, 1995.

[62] Huff, C. & Cooper, J. "Sex Bias in Educational Software; The Effect of Designers' Stereotypes on the Software they Design," *Journal of Applied Social Psychology*, 17(6), pp. 519-532, 1987.

[63] Huff, C. "Gender, Software Design, and Occupational Equity," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[64] Jepson, A. & Perl, T. "Priming the Pipeline," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[65] Johnson, C. & Swoope, K. "Boys' and Girls' Interest in Using Computers: Implications for the Classroom," *Arithmetic Teacher*, pp. 14 – 16, September, 1987.

[66] Johnson, D. & Miller, K. "Is Diversity in Computing a Moral Matter?" *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[67] Kantrowitz, B. "Men, Women and Computers," *Newsweek*, pp. 48-55, May 16, 1994.

[68] Kiesler, S., Sproull, L., & Eccles, J. "Pool Halls, Chips, and War Games: Women in the Culture of Computing," *inroads (SIGCSE Bulletin)*, 34(2), 2002. Reprinted from *Psychology of Women Quarterly*, 9, pp. 451-462, 1985.

[69] Kiesler, S., Sproull, L., & Zubrow, D. "Cultural Socialization to Computing in College," *Computers in Human Behavior*, 2(4), pp. 257-275, 1986.

[70] Klawe, M. & Levenson, N. "Women in Computing Where Are We Now?" *Communications of the ACM*, 38(1), pp. 29-35, 1995.

[71] Klawe, M. "Designing Game-based Interactive Multimedia Mathematics Learning Activities," *Proceedings 4th UCSMP International Conference on Mathematics Education*, Chicago, 1998.

[72] Klawe, M. "Girls, Boys, and Computers," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[73] Kolata, G. "Equal Time for Women," *Discover*, pp. 24-27, January, 1984.

[74] Lazowska, E. "Pale and Male: 19th Century Design in a 21st Century World," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[75] Lee, J.A.N. "Well Behaved Women Rarely Make History!" *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[76] Levenson, N. "Educational Pipeline Issues for Women," *CRA Snowbird Conference Panel Presentation*, July 1990, http://www.ai.mit.edu/people/ellens/Gender/pipeline.html (accessed March 14, 2002).

[77] Levin, T. & Gordon, C. "Effect of Gender and Computer Experience on Attitudes Towards Computers," *Journal of Educational Computing Research*, 5(1), pp. 69-88, 1989.

[78] Linn, M. "Fostering Equitable Consequences from Computer Learning Environments," *Sex Roles*, 13(3/4), pp. 229-240, 1985.

[79] Loyd, B. & Gressard, C. "The Effects of Sex, Age, and Computer Experience on Computer Attitudes," *AEDS Journal*, 18(2), pp. 67-77, 1984.

[80] Mahony, K. & Van Toen, B. "Mathematical Formalism as a Means of Occupational Closure in Computing - Why 'Hard' Computing Tends to Exclude Women," *Gender and Education*, 2(3), pp. 319-331, 1990.

[81] Makoff, J. "Computing in America: A Masculine Mystique," *New York Times*, February 13, 1989.

[82] Margolis, J. & Fisher, A. *Unlocking the Clubhouse: Women in Computing*. MIT Press: Cambridge, MA, 2002.

[83] Mather, M.A. "Mentoring Digital Style," *Technology and Learning*, 18(4), pp. 19–21, November/December, 1997, http://www.techlearning.com/content/about/archives/volume18/archives_v18.html (accessed March 14, 2002).

[84] McCormick, N. & McCormick, J. "Not For Men Only: Why So Few Women Major In Computer Science," *College Student Journal*, 25, pp. 345-350, September, 1991.

[85] MentorNet - The E-Mentoring Network for Women in Engineering and Science, http://www.mentornet.net (accessed March 14, 2002).

[86] Mertz, N. & Pfleeger, S. "Executive Mentoring: What Makes It Work?" *Communications of the ACM*, 38(1), pp. 63-73, 1995.

[87] Miller, L., Chaika, M., & Groppe, L. "Girls' Preference in Software Design: Insights from a Focus Group," *Interpersonal Computing and Technology: An Electronic Journal for the 21st Century*, 4(2), pp. 27-36, April, 1996.

[88] Miller, E. & Swanson, J. "Technology: Are We Helping Our Daughters?" *Tech Directions*, 57, pp. 20-21, 1999.

[89] Moroh, M. & Sturm, D. "Gender and Computer Science Majors: Perceptions and Reality," *National Educational Computing Conference*, pp. 189-191, 1995.

[90] Morrow C. & Perl, T. *Notable Women in Mathematics: A Biographical Dictionary*, Greenwood Press: Westport, Connecticut, 1998.

[91] Mounfield, L. & Taylor, H. "Exploration of the Relationship between Prior Computing Experience and Gender on Success in College Computer Science," *Journal of Educational Computing Research*, 11(4), pp. 291-306, 1994.

[92] Murray, T. "Gender Equity in the Mathematics Classroom:

Separate and Equal," *The Nueva Journal*, 36(3), Summer 1995, http://nueva.pvt.k12.ca.us/nj/nj-gender.html (accessed March 14, 2002).

[93] NSF. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2000*, National Science Foundation report, 2000. http://www.nsf.gov/cgi-bin/getpub?nsf00327 (accessed March 14, 2002).

[94] Parelius, A. & Sackrowitz, M. "An Unlevel Playing Field: Women in the Introductory Computer Science Courses," *SIGCSE*, pp. 37-41, February, 1996.

[95] Pathways. Math/Science Network, http://www.expandingyourhorizons.org/aboutpathways.html (accessed March 14, 2002).

[96] Pearl, A., Pollock, M., Riskin, E., Thomas, B., Wolf, E., & Wu, A. "Becoming a Computer Scientist," *inroads (SIGCSE Bulletin)*, 34(2), 2002. Reprinted from *Communications of the ACM*, 33(11), pp. 47-57, 1990.

[97] Perl, T. *Math Equals: Biographies of Women Mathematicians and Related Activities,*: Addison-Wesley: Menlo Park, California, 1978.

[98] Perl, T. *Women and Numbers: Lives of Women Mathematicians plus Discovery Activities*, Wide World Publishing/Tetra: San Carlos, California, 1993.

[99] Pratt, W. "Graduate School Survival Guide," March 5, 1997, http://www.smi.stanford.edu/people/pratt/smi/advice.html#advisor_relationship (accessed March 14, 2002).

[100] Scragg, G. & Smith, J. "A Study of Barriers to Women in Undergraduate Computer Science," *SIGCSE*, 30(1), pp. 82-86, 1998.

[101] Shashaani, L. "Gender-Based Differences in Attitudes Toward Computers," *Computers & Education*, 20(2), pp. 169-181, 1993.

[102] Shashaani, L. "Gender-Differences in Computer Experience and its Influence on Computer Attitudes," *Journal of Educational Computing Research*, 11(4), pp. 347-367, 1994.

[103] Spertus, E. & Gürer, D. "Women and Computing," an entry for Ralston, T., Reilly, E. and Hemmendinger, D. (Eds.) *The Encyclopedia of Computer Science*, 1998.

[104] Spertus, E. "Why are There so Few Female Computer Scientists?" *MIT Artificial Intelligence Laboratory Technical Report 1315*, 1991, http://www.ai.mit.edu/people/ellens/Gender/pap/pap.html (accessed March 14, 2002).

[105] Spertus, E. "Wit Helps Women in Computer Science Combat Ignorance," *inroads (SIGCSE Bulletin)*, 34(2), 2002. Reprinted from *Women in Higher Education*, May, 1997.

[106] Sproull, S. & Eccles, J. "Second-Class Citizens?" *Psychology Today*, pp. 41-48, March, 1983.

[107] Stanley, J. & Stumpf, H. "The Gender Gap in Advanced Placement Computer Science," *College Board Review*, 181, pp. 22-27, July, 1997.

[108] Struck, M. & Ware, M. "Sex-Role Messages Vis-a-Vis Microcomputer Use: A Look at the Pictures," *Sex Roles*, 13(3/4), pp. 205-214, 1985.

[109] Sturm, D., & Moroh, M. "Encouraging Enrollment and Retention of Women in Computer Science Classes," *Proceedings of the National Education Computing Conference*, pp. 267–271, 1994.

[110] Tannen, D. *Talking from 9 to 5*. William Morrow and Company, Inc.: New York, NY, 1994.

[111] Tannen, D. "The Power of Talk: Who Gets Heard and Why," *Harvard Business Review*, pp. 138-148, September-October, 1995.

[112] Thom, M. *Balancing the Equation: Where Are Women and Girls in Science, Engineering, and Technology?* The National Council for Research on Women: New York, NY, 2001.

[113] Townsend, G. "Viewing Video-Taped Role Models Improves Female Attitudes Toward Computer Science," *SIGCSE*, pp. 42-45, 1996.

[114] Townsend, G. "People Who Make a Difference: Mentors and Role Models," *inroads (SIGCSE Bulletin)*, 34(2), 2002.

[115] Travis, J. "Making Room for Women in the Culture of Science," *Science*, 260, p. 412, April 16, 1993.

[116] Treu, K. "Ten Suggestions for a Gender-Equitable CS Classroom," *inroads (SIGCSE Bulletin)*, 34(2), 2002. Reprinted from *The Journal of Computing in Small Colleges*, 12(2), pp. 244-248, November 1996.

[117] Walker, E. & Rodger, S. "PipeLINK: Connecting Women and Girls in the Computer Science Pipeline," *Proceedings of the National Education Computing Conference*, pp. 378-384, 1996.

[118] Wilson, F. "Language, Technology, Gender, and Power," *Human Relations*, 45(9), pp. 883-905, 1992.

FASE

Forum for Advanced Software Engineering Education

Online Newsletter

for educating and training software engineers

<http://www.cs.ttu.edu/fase/>