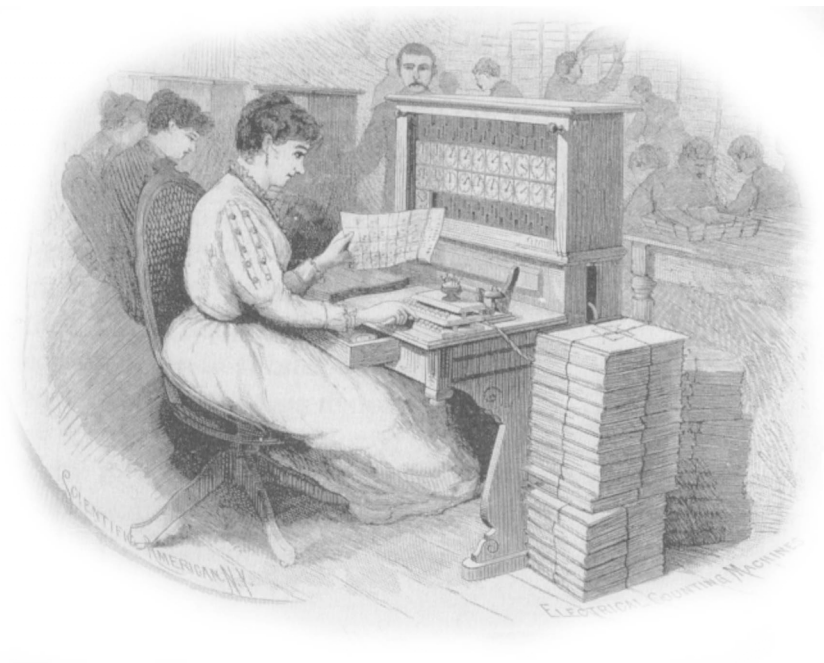


WOMEN AND COMPUTER SCIENCE
-A REVIEW OF COMPUTER ANXIETY
AND ITS RELATION TO COMPUTER
SCIENCE IN A HISTORICAL
PERSPECTIVE



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Introduction

There is no doubt that, in our society today, computers and their technology is a male domain. From playing computer games to studying computer science. The majority of computer games are created with boys in mind (Brosnan, 1998, 1) and the percentage of women majoring in computer science (and related subjects such as software development and information systems) is strikingly low¹. The woman who does not know how to use a computer has become a stereotype that is supported everyday in the media; the women are excluded from the world of computers because the media refer mostly to men. In computer sections of the newspapers men are writing most of the articles, men are reviewing the latest computer games, and educational TV programs about computers have male hosts. But why do women not have the same interest in computers and their technology than men?

An issue closely linked to women's lacking interest in computers and their technology, is the concept of Technophobia. Mark Brosnan discusses in depth in his book "Technophobia -the psychological impact of information technology" (1998, 1) the fact that women show a much higher rate of technophobia in many of the studies conducted through the last three decades. He argues that social learning affects not only girls own perception of their lack of abilities within technology, but it also affects *boy's* perception of girl's lacking abilities. This happens at an early age and the attitude that only boys are good with computers only gets stronger as the children get older. But is technophobia the same as "not interested in computers"? And is the gender division within the field of computer science the reflection of the difference in interest, or actually a difference in social upbringing?

This paper reviews some of the literature in regard to the subject of computer anxiety and computer attitude, and discusses its relation to the low enrollment of females in the field of computer science. To get a historical perspective of women's involvement in computer science, this issue is also discussed in relation to today's situation.

Method

Although the paper will be a review of the literature within the field of computer history and computer anxiety, it does not attempt to cover all the literature. The concept of computer anxiety (sometimes also referred to as technophobia) has been studied extensively and it would therefore be impossible to look at more than the most

¹ According to Little (1999), women earn 16 % of the master's degrees in computer science in The United States and the numbers are declining. In Denmark, Roskilde University has 41 women out of 210 student in the Department of computer science department (Author's own calculations from student lists, 1998).

relevant publishing of the subject. Therefore computer anxiety is only reviewed in regard to the gender difference, although many studies view “technophobes” as a certain group of individuals, regardless of gender. Also history of computers is a very broad area and therefore, only the most important issues are highlighted. Conclusions will be drawn upon the basis of the selected of literature.

Historical view of women and computer science

Computer science is a fairly new field of study and, although the first attempts to create calculating engines was made already in the beginning of the nineteenth century (Bromley, 1990, 1), the personal computer is new to most people. The computer is actually a general-purpose machine, developed from a number of early calculation- and computational devices used for numerous tasks, in early days one task for each machine. But even after its development from a calculating engine to an information-processing tool, the computer has continued to change. During the last three decades it has gone from being a business tool for few large businesses to be represented in homes as well as almost every work place.

The acclaim as the world’s first computer programmer has often been given to a woman mathematician, Ada Lovelace (Little, 1999; Camp and Gurer, 1999). She worked on the analytical engine designed by Charles Babbage in the 1840s and she is also credited with the development of the programming concepts of subroutines and looping (Goyal, 1996).

In the early days of the calculator, before the 1950s, many women were pioneers in the field. Since most men were in the armed forces during World War II the women were employed as *calculators* and *computers* using desk calculators (Goyal, 1996). It was common thought that women were ‘ideal candidates for programming’, because of their patience and persistence (Camp and Gurer, 1999, p. 242).

Although Babbage had already created drafts and attempted to build a calculator capable of being programmed in the nineteenth century, computers as viewed today, meaning a processing device capable of executing a stored program, were not developed before the 1950s (Aspray, 1990). Between the late nineteenth century and this time, calculations were carried out on calculators, such as punch card devices, all created for a specific purpose. The first calculators were for example used to count the population (The American Census Bureau was the first to use machinery for calculations in The United States, 1890) and for calculation of railroad and insurance statistics (Campbell-Kelly, 1990). In fact punch cards were used up until the sixties because of their mechanical reliability. But as the computer developed from an analog and mechanical calculator to a general purpose, digital device for stored programs, as happened through the fifties, female participants disappeared from the programming

field and into positions as data entry personnel and tape librarians (Bromley, 1990, 2; Little, 1999).

Two examples of other women who have contributed to the field of computer science in the twentieth century are Grace Hopper and Judy Clapp. Grace Hopper was one of the first programmers on Harvard's Mark I computer in the fifties and she is recognized for contributions to programming concepts such as subroutines, translation of formula and code optimization (Camp and Gurer, 1999). Judy Clapp served as programmer on the Whirlwind machine in the seventies, the first real-time computer and the first to use time-sharing (Goyal, 1996).

The Personal Computer

The biggest change in the field of computers, however, probably occurred with the development of the personal computer. In the late seventies/early eighties, the invention of the microprocessor made the so-called "micro-computers" commercially available for individuals. The first personal computer was market in 1976 from the company named Apple (Rosenberg, 1997). The company's vision was that computers were not just useful for businesses, but for individuals as well. However, in the early days of the personal computer, it was considered to be a toy, suitable for children and not the tool that it has since developed to be (Little, 1999). During the eighties and the beginning of the nineties, computers in the home were mostly used for games and word-processing, but with the spread of the Internet, computers have become even more common and useful.

Today computers are being used for more than calculations, games and word-processing. With the rising popularity of the Internet and the decrease of hardware prices, personal computers have become as common as to reside in 58% of Danish households, where 35% of these have access to the Internet (Dahlager, 2000). More jobs than ever require "computer literacy", because the personal computer have entered many work places; they are used in all fields, as word-processors, calculators, databases and tools for information search and inquiry (Shashaani, 1993). As a result, 41 % of all European citizens use a personal computer at their job² (Looms, 1999).

Because of this development, the subject of computer science and computer technology now includes more fields than ever. It is almost impossible to be an expert on computers in general; computer science students have to find specific subjects to emphasize. Today the subject includes hardware and software, programming languages, algorithmic, databases, networks and protocols (especially important in the age of the Internet), etc. Where computers, in earlier days, were operated by "experts"

² Note that this number is from 1998, it is very likely that the number is much higher today, because the same study showed that 33% of the Danish households had a computer and 24% were connected to the Internet.

or at least personnel specifically educated for operating one machine (e.g. the punch card calculators or mechanical analog computers used for statistics before the 1950s), the personal computer is today a general purpose machine, that is used in thousands of fields. The personal computer has numerous different programs, for numerous different tasks and in order to use a computer, it is necessary for the user to know how to use these programs, even if the person does not have a science-related education.

Technophobia and computer anxiety

It is evident that computers have had a great impact on our society through the last two decades (in particular). Perhaps a result of this rapid development has been a greater general fear of new technology; computer technology is one of the most wide spread technologies in the society today. Brosnan states that people have always been skeptical of new technology, from the car, to the telephone and the radio, but usually the fear has disappeared within a period of transition (1998, 1). He continues to speak of the advent of the computer: 'There was an original assumption that technophobia would be a transitory phenomenon, common amongst older adults who had missed out upon technology in their education ... [instead] children are getting increasingly computer anxious at an earlier age' (ibid., p. 11). Much research point to the fact that some people avoid computers over all and that they have very negative attitudes toward this new technology. Why that is, will be discussed further down, first, the concept of technophobia will be reviewed closer.

Computerphobia, as Jay named the phenomenon in 1981 (Weil and Rosen, 1995), is by Weil and Rosen defined to be evidence of one or more of the following:

- (a) anxiety about present or future interactions with computers or computer-related technology; (b) negative global attitudes about computers, their operation or their societal impact; and/or (c) specific negative cognitions or self-critical internal dialogues during present computer interactions are when contemplating future computer interaction (ibid., p.97)³.

Because many scholars (e.g. Brosnan) refer specifically to computers when speaking of technophobia, it has a more appropriate and focused term: computer anxiety. This term is, according to Brosnan, a part of technophobia because he refers to technophobia as containing both computer anxiety and computer attitude (1998, 1). However, in order to eliminate confusing terms, this paper will mainly use the terms "computer anxiety" and "attitude towards computers". Technophobia is a broad

³ Weil and Rosen's definition is an updated version of Jay's initial definition from 1981.

concept and the author believes that it would also include fear towards using TVs, VCRs, stereos as well as cars, because these devices all rely on new technology.

The concept of computer anxiety is, according to Brosnan, 'a real phenomenon' (1998, 2, p. 63). With this statement it is said that some people get anxious and nervous when faced with a task requiring the use of a computer. Returning to the definition of computer anxiety, it is reasonable to think that since computer anxiety has a high rate among females, females are then less likely to consider a field that includes computer in the title. It is obvious that individuals with one or more of these above outlined characteristics will not have the interest to enter or even take classes within the field of computer science. Although computer science includes subjects less technical and more mathematical, such as algorithmic, choosing a field in computers requires at least a non-fear relationship to computers.

As early as 1970, the issue of computer anxiety was addressed in a survey in The United States, but the nature of the anxiety has changed a bit during the last three decades (Brosnan, 1998, 1). In the early eighties, the reason to fear computers was often that they would take away people's jobs (e.g. Brad, 1983). Today the fear behind is more often that one will not be able to operate a computer and therefore will not be able to get a good job (e.g. Brosnan, 1998, 2 and Shashaani, 1993). Where the technophobia, in the 70's and 80's, was measured as a general negative attitude towards new technology, it was a direct fear of using computer technology that served as foundation for the research in the 90's.

In order to discover why some people become anxious when faced with at computer or computer related task, it is first relevant to take look at the correlated factors. Is computer anxiety a real fear or is it a lack of interest in computers in general? The next three sections are devoted to the review of some of the claims in regard to this question.

Experience Level and Interest

Experience level is a key word when discussing computer anxiety. Many studies have, according to Brosnan, found lack of experience working with computers to correlate with computer anxiety (1998, 1). But when conducting correlational studies, it is impossible to tell which variable is causing the other or if there actually is a cause-effect relationship. It is therefore not possible to tell if the higher level of experience causes the computer anxiety to decrease or if a lower level of computer anxiety causes individuals to acquire more experience. It is likely that both theories hold some truth, for example if individuals have positive thoughts of computers, they are more likely to take computer literacy courses. However, a study by Mahmood and Medewitz conclude that computer literacy courses can not change a negative attitude towards computers in general (1990). The same research suggest that even learning a

programming language can not change the negative attitude, this can only change the acknowledgement of IT capabilities. A study by Shashaani shows that when the computer anxiety is high, the interest in learning more is low (1993). What this suggests is that some people simply lack the interest in computers, and therefore choose *not* to engage in any computer related tasks. This results in a low level of experience and consequently these individuals show a higher level of computer anxiety.

The lack of interest is, however, not the complete explanation, but it indicates that people view computers different from the beginning. This is probably why some scholars conclude by explaining how important it is to educate the children in the general use of computers (e.g. Shashaani, 1993; Bruin, 1992). They highlight the importance of educating females because they often do not get the same attention in society, when it comes to computers (this subject is elaborated further down). Shashaani concludes her study: 'Educators are in a position not only to provide a better educational environment in schools to facilitate the computer education of females, but are also able to contribute to changing the perception of parents towards their children's abilities and opportunities' (1993, p. 179). What is often blamed for this difference between the genders is our society today. The critique is that computers are depicted as masculine and mostly a tool for males. Therefore the lack of interest is likely rooted in society's definition of gender-roles.

Females and computer anxiety

When viewing literature on the subject of technophobia and computer anxiety it is evident that there is a huge difference between gender and level of anxiety. Females of all ages are more likely to suffer computer anxiety and, as mentioned before and will be returned to later, this is probably one of the initial reasons why the female representation in computer science is very low.

Some studies have actually considered biological factors but the evidence has been insufficient; there has been support for difference in spatial abilities, but nothing that could not be trained away within half an hour (Brosnan, 1998, 1)! It is even questioned if spatial abilities or cognitive abilities are related to the ability to use computers (ibid.).

A large part of the studies in the area refers to the gender-role socialization as the main reason for this difference. Shashaani, for example, notes that men and women's different attitude is in fact 'a reflection of their social experiences, that is, the expectation of others, including family, friends, and society' (1993, p. 171). She continues referring to studies that have shown how parents and teachers encourage boys to engage in subjects of science and technology and girls to engage in more humanistic fields.

The historical role of the personal computer as a toy is not to be disregarded as a factor. When the personal computer was launched in the eighties, it was, as mentioned before, seen as at toy. It was probably difficult to see what purpose a mix between a typewriter and a video game console could be used for in the home, especially for females. As Brosnan notes, several studies have shown that females are more tool-oriented, meaning they will learn to use a computer if it serves as a tool, where males are more game oriented (1998, 1). Computing became a hobby with the introduction of the personal computer and often available as a kit in the electronics departments (Little, 1999). (It would perhaps have been a different world by now if it had been launched in appliance departments and bookstores, stores that are actually some times retailers for personal computers today) Furthermore, games were usually targeted males (and still are) for example did only four of the 32 covers of computer games, distributed in 1985, picture females (Camp and Gurer, 1999). An interesting factor in this connection is that interactive games traditional appeal to males. It is possible to think that since video games and other interactive games were already targeted males, it was easy to continue this tendency. It is also likely to think that because of the lack of women in computer science and programming fields, the developers of the games simply targeted their own "peers". This area of computer history is interesting; however, it is out of the scope of this paper to answer why computer games appeal mostly to males. Fact is that they do and that it has had wide consequences as will be elaborated in the section about the computer user and the computer scientist.

Almost twenty years later, personal computers are still marketed with males as target, and it is estimated that men purchase 99% of all computers (Brosnan, 1998, 1). Even educational software is overtly designed for boys (ibid.), a fact that supports the theory above that male software-developers create software for males⁴.

Brosnan argues that when a subject has acquired a masculine image, it is seen as an enhancement of masculinity and diminishment of femininity to participate in it. Furthermore, studies show that females will not perform as well as if a subject is considered feminine, perhaps as a result of the former. But in the context where technology is not masculinized, there is no apparent difference in performance between the two genders (1998, 1). This again, supports the notion of that gender-role stereotypes serve as a determinant of level of computer anxiety and interest.

⁴ It should be noted that Internet users have almost eliminated gender difference. 45% of the users are women (Dahlager, 2000). This issue is interesting, especially in regard to the present subject, however it is too broad for a paper of this kind and is therefore not dealt with here.

The role of society

The fact that our society perceives the computer to be a man's tool is mentioned by all the studied literature. The general notion is that it is the society as a whole that is structured with gender-role stereotypes. Joyce Currie Little, a professor in computer and information science, for example, notes that it is important that 'we look for solutions not in the women but in the structures and processes of our world' (1999, p. 204). Shashaani also notes that the attitude towards computer technology is, 'rooted in the way [children] are socialized in early education' (1993, p. 171). Therefore, she argues, computer anxiety should be studied at a much earlier state than beginning of university. This statement is consistent with a study by Brosnan (1998, 2) which conclude that one of the important determinants for level of computer anxiety is *who* introduced computers to the participant. If the introductory person was a friend or a family member, the participant was less likely to suffer computer anxiety than when it had been a teacher who introduced the participant to computers.

When comparing different countries and cultures, a study by Weil and Rosen attempts to cover technophobia's⁵ spread among university students in 23 countries (1995). The countries are not all western, they include for example Kenya, Egypt, Indonesia, Saudi Arabia, Singapore as well as nine European countries and The United States. The study finds technophobia to be less common in countries that emphasize 'comprehensive and well-integrated early computer education' (p. 129). Technophobia is present in all the countries with Israel and Singapore showing the lowest levels on average and Indonesia and India showing the highest levels. One notable finding is one that not all countries show a difference in gender. Only seven countries (among these, The United States where much of the other literature originates) show females to be more technophobic than their male-peers and three countries (Italy, Northern Ireland and Thailand) show males to be more technophobic. One answer to this could be that the study actually investigates technophobia and does not limit itself to computers. Therefore the study is not directly comparable with the other reviewed literature. However, the issue of gender is still evident in most studies of computer anxiety and is often related to the role of society.

The Computer User and the Computer Scientist

Much of the reviewed research does not distinguish between the different tasks that participants are asked to express feelings about. Usually the questions asked are very general; for example "do you agree that, generally, men are better at using computers than women?" (Brosnan, 1998, 2). And when asked if participants perceive

⁵ The study includes questions referring to other technology than computers and the general term technophobia is therefore appropriate here.

computers to be a male domain, the wording is equally general. There is no distinction between technical tasks such as programming and more soft tasks such as word-processing (except for in the cross-cultural study by Weil and Rosen, 1995, who ask several different questions such as “have you ever written a computer program?”). It is interesting that the scholars, who try to discover why some people are reluctant towards the general use of computers, make the mistake by not realizing that there is a difference. Perhaps the difference between genders is not always real, because females interpret questions differently from males. Perhaps the females interpret the questions like “do you feel good about computing?” as “are you good at programming applications?”. Furthermore, the male participants will perhaps interpret questions like “do you get anxious when you have a computing task?” as “do you get anxious when you have to type an essay on a word-processor?”. Questions like those can be interpreted in numerous ways and if this is the case, it is no wonder females show a higher level of computer anxiety; it is a lot harder to learn how to program than learn how to use a word-processor.

In the view of history, the personal computer has spread very fast to all parts of the society. It is interesting that because the computer was once a large machine, only operable by skilled technicians or computer scientists, some people still believe it to be just that: Only operable by certain people. The personal computer was developed with the average person in mind and it is reasonable to say that today, learning how to use word-processing, e-mail systems, Internet surfing etc. does not require any other skills than practice. Learning to use a computer for everyday tasks does *not* require the person to know a programming language. Neither does it require the person to know how the computer’s processor works together with the hard disc in order to compute the data. It is important to distinguish between at least some of the thousand tasks a computer can perform. They can not all be compared; as mentioned in the section of the computer’s history, it is a “general purpose machine” gathering several devices with different purposes. All they had in common was that they needed some numbers to be calculated fast. And this is still what all computers actually are able to do: calculate a lot of (binary) numbers fast.

Conclusion

Although women have had important roles through the history of computers, they are still strikingly absent from computer science departments today. Building the computers have always been a technical job and since males traditionally are perceived to hold more technical skills than females, it is therefore obvious (but still not necessary) that this job have ended in the hands of males. Programming however is a different issue. Today this still requires mathematics and logic skills, patience and

persistence like it did in the forties, something that is not necessarily perceived as masculine.

Some of the answers to the low enrollment of females in computer science are likely connected to the society's concept of the computer as a male tool. During the eighties and nineties, the proportion of females receiving computer science degrees has continued to decrease (Little, 1999) and studies show that in the beginning of the eighties, the perception of computer science as a hacker/nerd/anti-social field began. The personal computer made the computer available for almost anyone and the nerd became a stereotype, helped by the media who pictured personal computers as boys' toy and a very technical device. One common stereotype was, and still is, that computer science equaled hacking. The personal computer took over as the emphasized device (instead of larger mainframe computers) with the reputation as being something to play with instead of what the computer had been used for during the first forty years of its invention: calculation of numbers for productive purposes.

Another answer to why females stay out of computer related fields is that they are simply not interested. Many of the reviewed studies indicated that before actually being anxious of using computers, there was a lack of interest to even try. Again, this is probably related to the society's depiction of computers and gender-roles. Females are supposed to do good at feminine subjects and males are supposed to do well in the masculine areas, in order to fit in. One critique of the reviewed studies (e.g. Weil and Rosen, 1995; Shashaani, 1993) is that they do not elaborate on the interest issue. Lack of interest could easily appear as computer anxiety, because the participants do not have interest in computers and therefore feel incompetent when faced with one. It is therefore impossible to tell the two different motives apart and it is likely that they stem from the same factors within the society such as the gender-role stereotype.

One question that still remains unanswered is if computer anxiety leads to the low enrollment of females in computer science. In some way it does. The common stereotype of computers as a male area, leads to female's (and male's) perception that they will not be able to use a computer. This is in essence what computer anxiety is, a fear that one will not be able to perform the computer-related task that is needed. This keeps females initially from discovering what a computer can actually do and what computer science actually is. In Denmark, for example, programming and Information Technology is not yet defined as a compulsory class (some high schools offer computer science in the last year), meaning that when students have to choose their university major, they do not know what computer science is. Like with many other subjects (for example psychology, sociology, archeology and geology) they then rely on their own perception of the field, or if a person in their periphery possess skills within the subject. The disadvantage for computer science is not only the gender stereotypes but also that the common impression of the field is not true. Computer science does, as stated in the

section about the personal computer, include subjects that do not fit the hacker/nerd perception. More over, programming is very task oriented: a goal is set and in order to get there, one has to think hard and use logic skills, and there is never just one solution to the problem, there are better solutions and not so good solutions (also called spaghetti-code).

To end this paper, an analogy is proposed in order to emphasize the importance of noticing the difference between using a computer and programming one (or developing algorithms etc.). Imagine if some people refused to drive a car because they do not know what is inside the engine. They lacked the interest in getting to know about cars (perhaps because cars are perceived as a male domain), and therefore feared that they would not know how to press the break or shift gears. Fact is that a lot of women (and men) drive cars without knowing how to even change the oil. Likewise it is important to educate children as well as grown-ups in the use of computers without giving them the impression that it requires specific knowledge of for example RAM and processors. Today it is a very useful tool and it is necessary, not to learn to operate twenty different programs, but to learn to think differently about the computer in today's society.

References

- Aspray, W. (Eds.) (1990). *Computing Before Computers*. Ames, Iowa: Iowa State University Press.
- Bromley, A. G. (1990, 1). Difference and Analytical Engines. In Aspray (1990): 59–98.
- Bromley, A. G. (1990, 2). Analog Computing Devices. In Aspray (1990): 156–199.
- Brad, C. (1984). *Techno Stress. The human cost of the computer revolution*. Reading, Massachusetts: Addison-Wesley Publishing Company.
- Brosnan, M. (1998, 1). *Technophobia. The psychological impact of information technology*. London & New York: Routledge.
- Brosnan, M. (1998, 2). The Impact of Psychological Gender, Gender-related Perceptions, Significant Others, and the Introducer of Technology upon Computer Anxiety in Students. *Journal of educational computing research*, 18, 63–78.
- Bruin, A. M. (1992). A Century After Lady Lovelace' Tragedy. *Educaion and Society, Information Processing 92, vol. II*. 224–232.
- Camp, T & Gurer, D. (1999). Women in Computer Science: Where Have We Been and Where are We Going? 1999 *International Symposium on Technology and Society – Women and Technology: Historical, Societal, and Professional Perspectives. Proceedings, Networking the World*, 242–244.
- Campbell-Kelly, M. (1990). Punched-Card Machinery . In Aspray (1990): 122–155.
- Dalager, L. (2000). Danskerne Vælter på Nettet. *Politiken, January 20th 2000, Sec. 3, 2*.
- Goyal, A. (1996). Women in Computing: Historical Roles, the Perpetual Glass Ceiling, and Current Opportunities. *Annals of the History of Computing, vol. 18, No.3*. 36–42.
- Little, J. C. (1999). The Role of Women in the History of Computing. 1999 *International Symposium on Technology and Society – Women and Technology: Historical, Societal, and Professional Perspectives. Proceedings, Networking the World*, 202–205.
- Looms, P. (1999). *The European Multimedia Market and Industry – Trends and Statistics*. Copenhagen: Danish Broadcasting Corporation.
- Mahmood, M. A. & Medewitz, J. N. (1990). Assessing the Effect of Computer Literacy on Subject's Attitudes, Values and Opinions Toward Information Technology: An Exploratory Longitudinal Investigation Using the Linear Structural Relations Model. *Journal of Computer-Based Instruction, Vol. 16 No. 1*, 20–28.
- Rosenberg, R. S. (1997). *The Social Impact of Computers*. San Diego, California: Academic Press.
- Shashaani, L. (1993). Gender-based Differences in Attitudes Toward Computers. *Computers education, Vol. 20, No. 2*. 169–181.
- Weil, M. & Rosen, L. D. (1995). The Psychological Impact of Technology From a Global Perspective: A Study of Technological Sophistication and Technophobia in

University Students From Twenty-Three Countries. *Computers in Human Behavior*, Vol. 11, No 1. 95-133.

Front-page picture is taken from Aspray, 1990, page 78. It is part of the front-page on the National Scientific Review from 1890, showing a female calculating The United States Census statistics.