Cultural differences of female enrollment in tertiary education in Computer Science

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Abstract:

Since the establishment of computer science courses within the last 30-40 years both female enrollment and its development differ strongly between various continents, countries, cultures, religions and languages. It is very remarkable that female participation is extremely low in German (and Dutch) speaking countries, in Scandinavian countries and Great Britain, but that this is not the case to the same extent within the other European countries. In many Western countries female participation in Computer Science courses had dropped since the 1970ies to the half or less. This has not occurred in semi-developed countries, like the South American ones, the rich Arabic countries, the Tiger states or India, nor has it occurred in developmental countries, like the African, the poorer North African countries included.

Within our cultures the values of gender equality, freedom and deconstruction of gender differences often are used as arguments for a naturalization of these gender segregations in professions. But the observation of the differences in various cultures shows clearly that there are no inherent, but contingent reasons for such segregations. For example within the new countries of Germany it can be observed which effects reunion had on the female enrollment in Computer Science.

In this lecture after showing the numbers of female enrollment in tertiary education in Computer Science in various countries I want to give explanations and theories for these differences. It will turn out that there is no evidence for natural explanations of competence and interest in computing, as well as in mathematical and technical subjects. The findings in turn may give hints how to change the situation of women in Computing within our culture.

1. Some examples of female enrollment in Computer Science

A quick glanze at the proportion of female participation in science and engineering throughout the world (viz. tables below) reveals the extent to that gender distribution is culturally diversified. It is interesting to note that many of the so called industrially developed countries are comparatively underdeveloped as far as the inclusion of women into these subjects is concerned. Another interesting observation is that within Europe the former socialist countries have had and that the Latin countries are having a much higher female participation in science and engineering than the Anglo-Saxon, Scandinavian and German speaking countries. Within Europe Turkey, Spain and Portugal are doing best with respect to the inclusion of females in science and engineering in all stages of the career ladder. Also it is especially striking, that quite a lot of African, all the Arabic and South American countries have a nearly equal gender distribution in Computer Science.

Enrollment* for selected countries, showing total number of students and the percentage representation of females

	Natural science	Mathematics/computer science	Engineering

Country	Date	Total	%F	Total	%F	Total	%F
Angola	1990	609	40	na	na	799	21
Burkina Faso	1990	563	12	433	5	-	-
Burundi	1991	421	29	77	34	330	9
Ethiopia	1991	1700	6	468	9	2070	5
Ghana	1990	955	15	206	11	635	3
Kenya	1989	1966	15	na	na	854	4
Lesotho	1991	312	36	na	na	-	-
Niger	1989	280	6	na	na	98	4
Swaziland	1991	341	33	na	na	-	-
Uganda	1990	880	15	155	10	207	8
Zambia	1989	757	14	na	na	551	1
Zimbabwe	1991	1301	19	na	na	725	30
Kuwait	1991	1593	65	1635	72	1342	39
Brazil	1991	41158	49	70898	38	150015	17
Mexiko	1990	39541	54	51751	41	279989	16
Sweden	1991	3425	53	6504	19	20124	21

* Figures given represent enrolment in courses leading to a first degree.
na = not available because subsumed under another faculty.
Source: compiled from the UNESCO Statistical Yearbook, 1993.

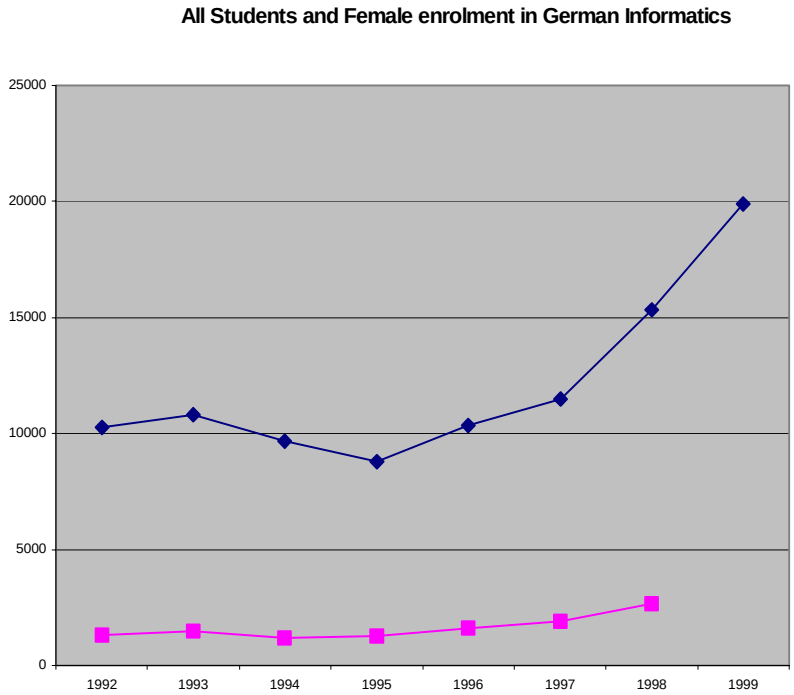
Some actual numbers from some single Universities show the striking differences as well (information by Joel C. Adams, Ph.D., who gives lectures in Mauritius 2001):

University of Mauritius: 40-50% women in CS courses
National University of Samoa: 60% of CS students are women.

2. The German situation in Informatics:

There has been a constant rising of students´enrollment since the nineteen seventies. But the female participation has not gone together with the male one. During the eighties and nineties the fraction of females even decreased substantially. In contrast the female participation in the former GDR was equally distributed among the sexes. The reunion of Germany however has brought the same situation also into the so called new countries (the former GDR).

The following table shows the overall situation in Germany during the nineteen nineties:



Source: own investigation.

The diagram shows the situation after the reunion of Germany, where also the participation of women in the new German countries from former East Germany have dropped to West German level. The following tables are showing the incredible degree of decline of females in Informatics within the new countries. Similar effects have occurred in Hungary (according to a colleague in Budapest ca 10% at the university of Budapest in 2000), but not in all of the former socialist countries.

Full-Time all GDR University Computer Science (Informationsverarbeitung), Majors 1969-86

	Enrollments			New Admissions			Graduates		
Year	Total	Women	W as %	Total	Women	W as %	Total	Women	W as %
1969	350	265	75.71%	309	228	73.79%			
1970	921	438	47.56%	459	192	41.83%	0	0	
1971	1353	644	47.60%	465	219	47.10%	0	0	
1972	1637	853	52.11%	376	261	69.41%	51	34	66.67%
1973	1445	810	56.06%	260	179	68.85%	393	190	48.35%
1974	1253	766	61.13%	280	166	59.29%	406	175	43.10%
1975	1071	674	62.93%	261	141	54.02%	386	206	53.37%
1976	932	543	58.26%	218	97	44.50%	301	202	67.11%
1977	841	442	52.56%	167	81	48.50%	224	162	72.32%
1978	736	349	47.42%	157	65	41.40%	239	146	61.09%

1979	688	315	45.78%	120	69	57.50%	138	88	63.77%
1980	583	297	50.94%	145	80	55.17%	205	73	35.61%
1981	550	299	54.36%	148	96	64.86%	155	76	49.03%
1982	633	349	55.13%	214	126	58.88%	104	57	54.81%
1983	710	418	58.87%	233	146	62.66%	1101	51	46.36%
1984									
1985	1024	550	53.71%	351	189	53.85%	129	74	57.36%
1986	1338	732	54.71%	500	296	59.20%	124	75	60.48%
Totals				4663	2631	56.42%	2965	1609	54.27%

Source: Dolores L. Augustine

Effects of the reunion of Germany on the female enrollment in Computer Science

at the Technical University of Rostock (source University of Rostock):

		All	Female	% of female CS-students
WS	1986/87	60	39	65 %
WS	1987/88	60	39	65 %
WS	1988/89	133	49	36,84 %
WS	1989/90	205	65	31,70 %
WS	1990/91	241	49	20.33 %
WS	1991/92	241	43	17,84 %
WS	1992/93	261	44	16,86 %
WS	1993/94	255	39	15,29 %
WS	1994/95	236	36	15,25 %
WS	1995/96	262	31	11,83 %
WS	1996/97	294	25	8,50 %
WS	1997/98	324	28	8,64 %
WS	1998/99	359	30	8,36 %

and at the Technical University of Chemnitz:

Beginners Informatik Technische Universität Chemnitz, Fachbereich Informatik

year	sum	male	female	female percentage
1984	25	18	7	28
1985	50	38	12	24
1986	100	80	20	20
1987	100	72	28	28
1988	110	92	18	16
1989	110	91	19	17
1990	110	88	22	20

1991	105	99	6	6
1992	70	67	3	4
1993	56	54	2	4
1994	53	51	2	4
1995	56	51	5	9
1996	67	64	3	4
1997	70	61	9	13
1998	78	74	4	5

Diploma in Informatik at Technische Hochschule Chemnitz

year	sum	male	female	female percentage
1989	22	15	7	32
1990	42	30	12	29
1991	79	60	19	24
1992	83	56	27	33
1993	67	53	14	21
1994	70	57	13	19
1995	51	40	11	22
1996	54	48	6	11
1997	38	35	3	8
1998	39	37	2	5

Source: Studenten- und Prüfungsamt Universität Chemnitz

3. The Shrinking Pipeline:

A different, but also context dependent effect is the shrinking of female enrollment in Computer Science in some countries, like the USA [Ca 97], in German (and Dutch) speaking countries, in Scandinavian countries and Great Britain and in Israel, often in contrast to all other subjects. In general in Western countries the interest in science and technology is sinking in second and third level education. Rising numbers are only seen in China, India and in the four Tiger countries. Within this general trend female percentages in western societies are rising in proportion within these subjects. But even in this general situation female participation has fallen in Computer Science since 1985, e.g. in Germany or Israel up to a half or more.
There has been no such effect in the Latin countries at the same time. In other countries, like Turkey, where the number of women taking computer education was constantly high as well, a decline has started later at the end of the nineties, probably due to the introduction of the Internet (personal information by a Turkish colleague).

The shrinking pipeline is shown first along with the percentage of women studying in Israel's universities. The following table lists the development of female students enrollment within Computer Science in the first

line; the following lines are showing the development of female enrollment in all subjects and status categories at Israel's Universities:

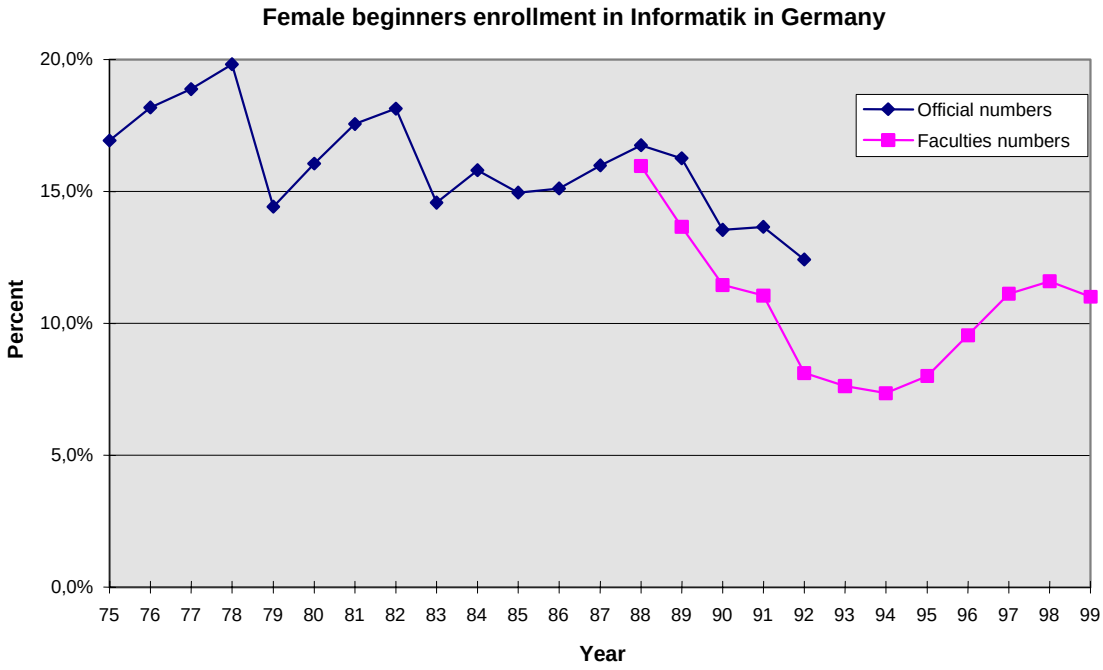
Percentage of women in universities in Israel: (all Israel/Technion)

% females	1974/75	76/77	78/79	81/82	88/89	92/93	94/95	95/96	76/77-95/96
CS+Math. Students		41		36	33	35		34	- 17%
Full Prof./Technion			4.6			7,3	/3,5		
Ass. Prof/ Technion			7,7			14,2	/10,0		
Sen. Lectr./ Technion			16,7			30,0	/15,0		
Lecturer/ Technion			28,9			36,6	/14,8		
Students total	42,8								
For 1st deg/get 1st deg	44,8/42,5						/55,3		
For2nd deg/get 2nd deg	35,2/33,5						/49,7		
For phil.D/get phil.D	25,9/17,2						/39,0		

1998 20% BS students in CS, 21% MS students in CS and 31% phil. Dr. students in CS.

Sources: Information on Equality, 8, August 1997, Publication of Edva Center, P.O.Box 36529, Tel-Aviv, 61364 and Prof. Dr. Rachelle Alterman alterman@tx, Architektur, Frauenbeauftragte des Technion, Haifa.

Also the **German female enrollment in CS** shows the shrinking effect through the last 15 years, but it also shows a slight improvement during the last two years (the latter, although highly appreciated, is not yet understood: it could be a result of the enforcement of the labor market due to the lack of computer professionals in Germany, and/or of the summer university Informatica Feminale in Bremen, which gives women a lot of encouragement, the more diversified Informatics courses, with possibilities for interdisciplinarity, and/or of the rising availability of computers in families, also for girls, and/or of the new and more social qualities of software, availability of better computer games , etc.).



4. Additional diversification of female enrolment according to University types

Tracy Camp found that CS departments in engineering colleges graduate, on average, proportionally fewer women than CS departments in non-engineering colleges. On the other hand at the level of Ph. D. degrees the percentages, though still meagre, increased. This is observed since more than 10 years in the US. We find that the same effect has occurred recently in Germany as well, with Technical Universities as opposed to classical (Humboldt) universities and especially to interdisciplinary courses of study in Informatics – and that the percentage of female assistants willing to achieve a Ph.D. in Informatics is often larger than the percentage of Informatics students.

Technical Universities: Diploma Courses in Informatik WS 98/99

		First Year Course Informatik			All **Informatik-Students**		
		Sum.	**fem.**	**% fem.**	Sum	**female**	**% female**
Aachen	RWTH	457	48	**10,5 %**	1660	131	**7,9 %**
Berlin	TU	425				2057	
Braunschweig	TU	140	13	**9,3 %**	873	62	**7,1 %**
Chemnitz	TU	76	4	**5,3 %**	310	23	**7,4 %**
Clausthal	TU	44					
Cottbus	TU	98	15	**15,3 %**	206	27	**13,1 %**
Darmstadt	TU	295	17	**5,8 %**	1005	109	**10,8 %**
Dresden	TU	262	29	**11,0 %**	731	60	**8,2 %**
Ilmenau	TU	135	10	**7,4 %**	538	31	**5,8%**
München	TU	443	65	**14,7 %**	1409	149	**10,5 %**
Sum	**TU/TH**	**2.375**	**201**	**8,5 %**	**8.789**	**592**	**8,85 %**

Classical Universities: Diploma Courses in Informatik WS 98/99

		First Year Course Informatik			All **Informatik-Students**		
		Sum.	**fem.**	**% fem.**	Sum	**female**	**% female**
Berlin	FU	181				385	
Berlin	Humboldt	366				933	
Bonn		312	52	**16,6 %**	1.538	160	**10,4 %**
Bremen		209			864	115	**13,3 %**
Dortmund		431	72	**16,7 %**	2.189	196	**8,9 %**
Erlangen-Nürnberg		209			816		
Frankfurt		226	49	**21,7 %**	985	140	**14,2 %**
Freiburg		101	19	**18,8 %**	299	30	**10 %**
Halle-Wittenberg		75	4	**6,0 %**	203	8	**3,9 %**
Jena		83	15	**18,1 %**	305	30	**9,8 %**
Kaiserslautern		133	12	**9,0 %**	592	50	**8,4 %**
Karlsruhe		282	31	**11,0 %**	1.372	219	**15,9 %**
Kiel		102	14	**13,7 %**	460	36	**7,8 %**
Koblenz-Landau		118			672	82	**12,2 %**
Leipzig		135	13	**9,6 %**	428	39	**9,1 %**
Lübeck Med.Univ.		86	23	**26,7 %**	265	54	**20,3 %**
Magdeburg		135	19	**14 %**	428	39	**9,1 %**
Marburg		95	15	**15,8 %**	295	29	**9,8 %**
München	U BW	47				143	
München	LMU	174	53	**30,5 %**	571	102	**17,8 %**
Oldenburg		142	20	**14 %**	761	63	**8,2 %**
Paderborn		175	23	**13,1 %**	1.142	92	**8,0 %**
Passau		179	27	**15 %**	363	75	**20,7 %**
Potsdam		94	18	**19,1 %**	204	31	**15,2 %**
Rostock		120	11	**9,2 %**	357	16	**4,5 %**
Saarbrücken		197	40	**20,3 %**	1.152	127	**11 %**
Stuttgart		212	26	**12,3 %**	896	85	**9.5 %**
Trier		38	4	**10.5 %**			
Tübingen		101	26	**25,7 %**	477		
Ulm		145	18	**12,4 %**	608	46	**7,5 %**
Würzburg		155	34	**22 %**	365	45	**12,3 %**
S u m of Informatik-Students at Classical Universities							**11,11 %**
Hagen Distance-University		1.735	316	**18,2 %**	4.720	837	**17,1 %**

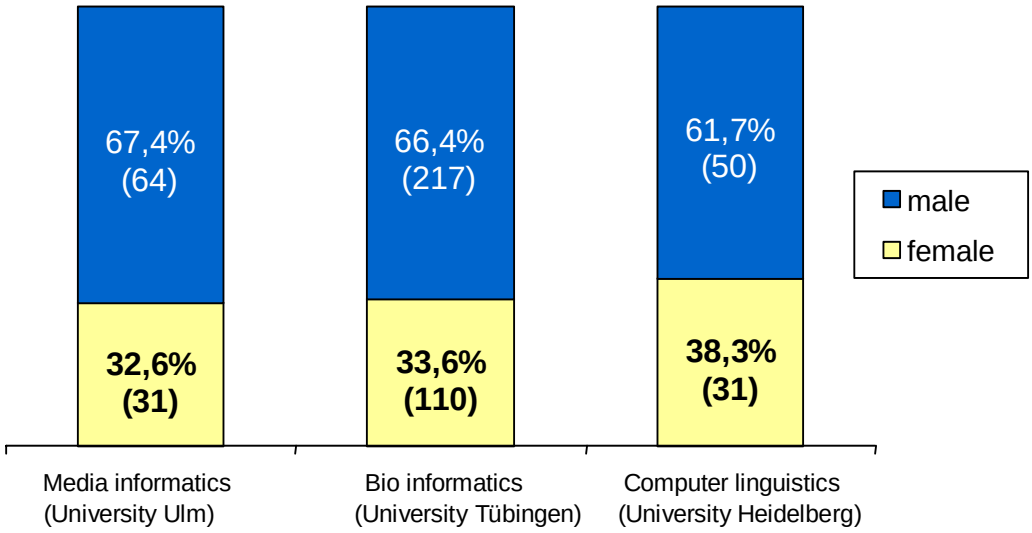
Source: Fakultätentag Informatik

More specialized courses recently are showing significant particularization effects of gender differences as well: the more technically defined (i.e. named) the less female participation and the more interdisciplinary and application defined, the larger the female participation (e.g.: FH Furtwangen 2000/01: Technical Informatics 0,0% females, Media Informatics 27,8% females).

We have recently investigated in the participation of women in IT work force as well as at all types of tertiary education within the province of Baden-Württemberg. Especially on the educational sector there is a strong dependency on contexts. The more emphasis in “dressing” and description is put on technology and engineering, the less women are interested ([Sch 01]), the more the subject is considered as interdisciplinary, the more it is put into social context, the more women are participating, even if the very subject is mostly technical (like media informatics).

University Informatics courses with more than 30% females are shown below (see [Hu 01]).

Specialized Informatics Courses with more than 30% females at Universities in the Province of Baden-Württemberg:



Sources: Universities of Ulm, Tübingen and Heidelberg.

5. Interpretations of gender differences in Computer Science between different cultures

The factors attributed to the diversification of gender differences existing between the “industrially developed”, the “semi-developed” countries, like the South East Asian and the South American ones and the "developmental" countries, like the south Sahara African countries are among others the class system, the different roles of universities, and the rate of income in science and engineering.

The class system has been predominant in the “semi-developed” countries (like India, Brazil or Argentina), where only the upper class people could afford to send their children to university and they equally let their boys and girls to study. Especially in these countries, there seems to be no conviction like in the North-West stereotyping women as less capable of pursuing education in science and technology. Another important factor there is that household and childcare works which are supposed to be the spheres of the females are delegated to employees, a fact which enables these women to join in the labour market with commitment just like men. Moreover, it is presumed (wrongly, as is obvious e.g. for India or Korea) that the university standards are considered to be not as competitive and high as in the “industrially developed” countries, making the courses of study less hard and stressful. Besides, the emphasis of these universities is supposed to lye more on educational than on scientific level, a circumstance which poses studying and university careers closer to standard female gender roles. As a consequence the teaching personnel in these countries is less gender diversified, giving role models for women as well. But again India and the four Tiger states cannot be put into this scheme and it is quite ironic to note that especially in these countries there seem to be strong differences with regard to cultural/symbolical constructions of gender.

The extremely high participation of women in engineering and computer science within the *North African and the Arabic countries* can be explained by the gender splitting also at universities. There is no coeducation on any level of education in these countries. That coeducation, especially during puberty, hurts female participation in science and engineering is widely explored, especially in the north-western countries of Europe and America. But it is important to note that it does not hurt everywhere (e.g. Italy)!

The very high participation of women in technology in the former *socialist countries* is giving rise to a different complex of causes and explanations. There gender equality was always pronounced (although a glass ceiling also existed in a more subtle way [Au 99]), whole day kindergartens existed for every child and 98% of all women in the respective age class worked. Until the nineteen hundred-eighties the stream of students was directed according to communist ideals, like future technologies and gender equality, but also to the needs of the work market. Of course this also forced many women into science, mathematics and technology, contrary to their interest, as Dolores Augustine rightly observes. Also at schools more emphasis was put onto science and engineering than in the west and all pupils could gain experiences with technology by the obligatory training in "polytechnic education" in firms [Ha 92]. Among others, Breckler et al. have found that the practical acquaintance with technology is extremely important to find interest, experience and finally also to decide for a respective profession [Br 91]. All this might explain why so many women were studying Informatics.
But why did the percentage collapse immediately after reunion? This is easily explained: there was an explicit policy to draw women from the job market. Kindergartens were closed, (from the "old countries of Germany" imported) politicians declared that female work had to reduce to a "normal" (i.e. West German) size. From 1990-1992 most jobs in the former DDR were evaluated (abgewickelt), a procedure where most people lost their jobs. In engineering men regained their or other jobs, women not [Bu 97]. Of course this was not encouraging for taking up a study in Informatik or engineering. The effect is the one which was seeked for.

Particularly interesting and difficult to explain are the considerable differences within Europe, which show less gender segregation in the Latin and the Slavonic countries, as well as in Turkey, than in Great Britain, the Scandinavian and the German speaking countries. These facts are directing attention away from structural reasons towards differences in the symbolic meaning of the gender - technology relation [Gri 93]. This might give explanations for the diversification according to the types of Universities in Germany as well.

There seems to exist a deeply founded desire to "perform gender" in some way or the other. If gender differences are institutionally guaranteed or performed by a visible marking, like dressing order or hairstyle/beard, or by a clear hierarchy within family work this performance of gender can be satisfied. This seems to hold also for the Catholic Latin and Slavic cultures within Europe, where a stronger body performance of gender is shown than in the Protestant cultures. In the Catholic countries there exist more specified gender cultures, which allow the individuals of both sexes self - conscious gender identities. This cultured behaviour is performed mainly in social interaction between men and women off workplace and it confirms their respective self-esteem as women or men. At the Balkan and in Italy, Spain and Portugal, there exist very distinctive and self confident gender cultures, both concerning the role of mothers of all generations and amongst the youth meeting and showing off at open places. In Russia the common conviction that men are

incapable of organizing everyday life (and often also the professional life) gives women a fairly self conscious gender identity, still not putting differences into question. So there is no necessity for boys or men to hold their ground in mathematics, science or engineering to stabilize their male identity and women can more easily consider themselves of equal intellectual ability, including fields like computer science. They need not take distance from engineering and IT to perform femaleness, as it is often observed in the North-Western European countries [Sch 99].

Within the Protestant cultures there is a greater tendency to hide body and sex, to equalize dressing and large parts of the habitué. With the additional dissolving of gender differences in law and other institutionalised forms a *"particularization of gender difference"* has appeared, i.e. in some areas these differences are disappearing, in others they are rising [He 98]. Societies tend to uphold gender hierarchies by reproducing gendering, especially in highly respected fields, like IT. Therefore it appears that there exists a need in the latter cultures to create the difference individually and by deliberate action and that this action has to be marked symbolically. As a consequence gender differences evolve context dependently, and their creation becomes a process with many prerequisites bound to specific constellations and to different areas of human activity. Therefore in certain contexts gender differences can be dissolved whereas in other ones they can be maintained or even be strengthened, like it is the case within the higher valued IT job market in some areas of the world. Bettina Heintz and Eva Nadai [He 98] showed for Switzerland how this effects on different gendering in various professions: in administration and organisation gender difference plays a role only concerning highly ranked positions, whereas within the nursing and the computing professions it is remarkable at all levels of studies as well as employment. The deepening of gendering of highly respected subjects, like computing, during the last 20 years in Germany and other countries documents this development as well (see [Sch 97]). as well as very low social
Though gender as a factor of ordering society loses its importance in the north-western European countries in general, it shows considerable persistence with respect to hierarchical structures, and it even gains importance on the symbolic level for the ordering of content, of scientific subjects, of specific professions. The contextualisation of gender difference might be caused by the open space, leaving the definition of gender identity much more to chance and to the individual. Unfortunately this free space frequently is not used in the sense of creating an identity which includes equal value. The gendering of competence creates a symbolic gendering of subjects, and with this also borderlines between and social closures for men and women.

The theses mentioned above also give explanations for the shrinking pipeline in Computer Science throughout the USA and the north-west European countries (all Protestant culture): gender difference can be created using the rising importance of information and communication technology. It leads boys and men to usurpation of these fields, in order to fulfill the social pressure on superiority to and better income than women.

Ways out of this situation have to detach gendered symbolic meanings from technological subjects. For deconstructing this gender-technology relation it is necessary to consider the various technological items in a differentiated way, i.e. to ask for the concrete content, the necessary competence in the field, and to investigate in the symbolic gender attachments. Examples of such deconstruction work are done in [Er 96] showing the impossibility of female computer scientists to identify with technological work and in [Sch 01] starting from

the subjects within computer science named with the label engineering, like software engineering, usability engineering, human centered engineering, or ontology engineering. It appears that all these subject require competence also in subjects far from mathematics and technology, i.e. in organizational, psychological, sociological or philosophical one [Sch 01]. On the other hand the fact that those subjects in computing which clearly have formal and technological character, like compilers or operating systems, image processing etc. are not marked with technological, and that also means gendered meaning, reveals some politics, as to my opinion the politics of closure of the profession against the non-technological subjects mentioned above. Unfortunately with this politics also a closure against women is performed, because as has been pointed out, their interests are leading into interdisciplinary subjects which are hidden under the engineering names.

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