tripleC 4(2): 303-314, 2006
ISSN 1726-670X
http://tripleC.uti.at

Overcoming the socio-technical divide: A long-term source of hope in feminist studies of computer science

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Abstract: The dichotomy of the technical and the social is strongly gendered in western thought. Therefore, potential dissolutions of the socio-technical divide have always been a source of hope from a feminist point of view. The starting point of this contribution are recent trends in the computer science discipline, such as the new interaction paradigm and the concept of 'social machines', which seem to challenge the borderline of the technical as opposed to the social and, thereby, refresh promises for changes in the gender-technology relationship. The paper primarily explores the entanglement between the socio-technical divide and the structural-symbolic gender order on the basis of historical academic discourses in German computer science. Thereby, traditions of critical thinking in the German computer science discipline and related feminist voices are introduced. A reflection of these historical discourses indicates that 'interaction' and 'social machines' are contested zones, which call for feminist intervention.

Keywords: computer science discipline, feminist theory, socio-technical divide, gender-technology relationship, interaction paradigm

Acknowledgement: This article was written in the research project "sociality with machines" (April 2004-July 2006), funded by the Austrian ministry for Education, Science and Culture. I am grateful to Adrian de Silva for his support in translation.

1 Introduction

Gender studies are in computer science mostly understood as the question of how to include more women. This assumption contains two shortcomings. First, gender is reduced to women, i.e. the problem is only seen as motivating them to study the subject or in supporting their entry into an IT occupation. Second, computer science is regarded as neutral, i.e. the discipline itself, its theoretical foundations, concepts and products seem to be given, technologically determined and independent of social and cultural influences. Science and technology studies as well as feminist scholars contrasted these views with theoretical arguments and empirical evidence for the social shaping and the gendering of technology use and design processes (e.g. McKenzie/Wajcman 1985/1999, Bijker/ Law 1992, Cockburn/Ormrod 1993, Wajcman 2004). Several of these studies focussed on computer science and information technologies (e.g. Hapnes/Rasmussen 1991, Adam et al. 1994, Erb 1996, Adam 1998, Crutzen 2000, Kreutzner/ Schelhowe 2002, Archibald et al. 2005, Björkman 2005).

The expanding corpus of knowledge on gender- (information) technology relation, however, has rarely been noticed within the scope of computer science discipline. Mainstream discourses hardly acknowledge these critical approaches presumably because of their focus on the use context of technology, the use-design split or the Internet, while implicitly arguing that these topics were not legitimate subjects of

research and teaching in this field. A narrow technological view of computer science seems to function as a gatekeeper that keeps both, social aspects and gender perspectives, out of the discipline.

While contested throughout the last three decades such a limited understanding, is nowadays challenged by the new paradigm “interaction”, particularly by the recent rise of “social machines”. From a gender studies viewpoint these inner-disciplinary developments raise the question whether old gendered hierarchical patterns will be stabilized or if “gender” and feminist theory might become integrated within the computer science discipline at universities.

In order to explore the connection between the socio-technical divide and the structural-symbolic gender order more generally, my contribution examines historical discourses in the academia of computer science. In the German context I identified three debates, in which the borderline between the technical and the social has been negotiated: the debates on practices of software development, on disciplinary foundations and on the understanding of the computer technology. The question to be explored from a feminist perspective is what we can learn from these historical discourses, in order to take advantage of current trends towards “interaction” and “social machines” in, which again promise to overcome the socio-technical divide within the computer science discipline.

2 Paradigm shift to interaction

The starting point of my contribution is the ongoing hype about interaction that can be observed in mainstream discourses in computer science and in gender studies of the discipline. In 1997 the well-known US computer scientist Peter Wegner (1997) stated a paradigm shift within computer science from algorithms to interaction. He argued that the new computer systems are embedded, distributed and interactive. Computer scientists work with workstations and networks, and develop graphic user interfaces. Computing now is object-oriented and agent-based replacing dated “number-crunching” via mainframes and procedure-oriented programming. In AI, too, approaches based on logic and symbol-orientation shifted to multi-agent systems and behaviour-based robotics.

In these turns the concept of the Turing machine and that of von Neumann’s architecture, on which computer science was based for a long time, are overcome. The old “computational metaphor“, which understands computation as a function from its inputs to its outputs made up of a finite sequence of functional steps, is displaced (cp. Stein 1999). In the face of the new developments conventional algorithms appear to be “dumb”, “blind” and “autistic” (cp. Wegner 1997) because they cannot adapt interactively to the technical and non-technical environment during runtime, nor can they react to user intervention. Since objects in the current object-oriented programming paradigm “send messages“ to each other, software agents “communicate“ in multi-agent systems, and humans and machines “interact“ via the user interface, concepts of the social have entered computer science.

2.1 ‘Social machines’

This integration of the social into the discipline is even more explicitly expressed in the conceptual constructions of ‘emotional’ software agents and ‘socially intelligent’ robots (e.g. Cassell et al. 2000, Trappl/ Petta/ Payr 2002, Breazeal 2002, Dautenhahn 2002). These artefacts, which are currently developed in laboratories, are supposed to engage in social relations with humans in future. They are expected to recognise our feelings and empathise with us. Researchers promise that they are going to be our friends and playmates in the near future (cp. de Rosis 2001, Stern 2002). In some scenarios they are envisioned as children and pets, in others they are going to serve users as butlers. Social competencies are inscribed into the machines so that they can engage socially and emotionally with us human beings, and vice versa. Aspects of “natural“ communication, including body language and its meanings, are modelled and formalised as well as elements of feeling and showing emotions. The agents are given a personality so that they obtain a specific character (e.g. Trappl/ Petta 1997). They are, e.g., supposed to have a sense of humour or to be empathetic.

Social software agent researchers and roboticists base their knowledge of the social on scientific studies of human behaviour. They draw upon insights in psychology, cognitive science or biology as well

as approaches in communication and media studies. The goal is to model machines with social abilities according to human interaction and interpersonal relationships. If these dreams were to materialise, the border between the technical and the social would fall for good before long.

3 Dichotomies in feminist thinking and recent technoscientific developments

Since the dichotomy of the technical and the social is profoundly gendered in western thought, the dissolution of the borderline is appreciated from feminist side. Feminist theoreticians have shown that the idea of gender difference is written into traditional dualisms of western culture, such as body and mind, rationality and emotionality, and nature and culture (cp. Gatens 1991). Some of these dualisms are becoming blurred in the course of recent techno-scientific developments (cp. Haraway 1991). Regarding the current rise of interaction concepts in computer science, I claim that this tendency of dissolution also applies to the socio-technical divide. The approach to focus on the socio-technical divide is chosen carefully. While feminist studies of computer science during the last decade primarily investigated into the design-use relationship (Suchman 2000, Crutzen 2000, Bratteteig 2003), the orientation towards the technical and social provides a broader frame to capture the multifaceted entanglements between gender and computer science. The socio-technical divide is not only associated with software systems design and use, but may also include formations of the discipline as well as its meaning construction processes.

Following Donna Haraway the question arises whether the stated paradigm shift towards interaction can be perceived as a departure from male connotations of the computer science discipline or as a continuation of familiar hierarchical patterns. Will the destabilisation of the socio-technical divide provoke an even stronger adherence to concepts of stereotyped gender difference and to the hierarchical gender order? Or will chances arise for feminist intervention and change within the existing gender relations?

My approach to address these questions, here, is to analyse those discourses in the German computer science discipline during the last 30 years, which questioned traditional borders between the technical and the social. By re-reading historic debates I will examine in depth the assumption that the transgression of the narrow formal engineering focus of computer science opens up room for changes in the structural-symbolic relationship of gender and technology. Central arenas in which the border between the technical and the social has been negotiated are the debates on appropriate practices of software development, on the scientific foundation of the discipline, and on an understanding of the new technology. The three debates have in common that they present marked positions that either guard the border of the technological or argue in favour of a transgression toward to social.

4 Three debates in the German computer science discipline

4.1 Debate on software development practices

The first debate in which the social permeated the technical emerged during the 1970/1980ies, when socio-technical and participatory design approaches challenged the orientation towards engineering that dominated systems design since the so-called software-crisis.1 Critical approaches directed the attention to the users, the organisational embedding, and the social context of software systems opposing engineering methods, which rested on three pillars.

The method of structured programming (Dijkstra 1968) constituted the precondition for building software based on a division of labour and an industrial production process. According to this programming method complex programmes are partitioned top-down into modules, and GOTO statements are avoided, in order to reduce complexity and to produce comprehensible code. The waterfall model (Royce 1970), which constituted the industrial standard for a long time to follow, divided the software development process into the phases of requirements analysis, systems design, implementation, testing, and operation, including maintenance, and demanded a strict sequential action. Based on the waterfall model software development was practiced according to engineering work, aligned to an industrial occupation, and it

1 The term software crisis and the idea of software *engineering* appeared simultaneous (Naur/Randell 1969)

allowed for a taylorist organisation. In this way software production evolved as a controllable, calculable process, organised on the basis of economic principles.

Structured analysis (deMarco 1978) supplemented the technological canon of methods with graphical techniques such as data-flow diagrams. Its focus on algorithms and data structures turned the attention to formal-mathematical aspects of the modelling process. Although these methods advanced (cp. Boehm 1988) before they were displaced by object-oriented concepts they still stayed within the metaphor of "building" software technology within an early capitalistic industrial setting.

Proponents of the socio-technical approach, on the other side, suggested the joint optimisation of technical and social components in an organisation. They argued that job satisfaction and a humanisation of labour is a necessary precondition for effective industrial production. With regard to software development, empirical methods from the social sciences were adopted to requirements capture and analysis. Also ergonomic studies and usability testing evolved in order to improve software prototypes and products (Mumford 1987).

Participatory approaches of the Scandinavian School criticised the socio-technical approach because of its management orientation. Starting from left, unionist perspectives of the 1970ies, more precisely from the antagonism of capital and labour, proponents of the collective resource approach sought to side with employees via technology design (Ehn/Kyng 1987). The latter tradition of participatory design focussed on workplace democratisation, while others strands aimed to democratise the software development process. The cooperative design approach, in particular, provided methods such as visuals tools and communication techniques, in order to support an equal communication between developers and users (Bjerknes/Bratteteig 1994). With that they reflect upon the fact that developers traditionally possess of the model power (Bråten 1973), which renders it hard for users to participate equally in the process of system design.

Christiane Floyd was one of the leading software engineering researchers who introduced Scandinavian participatory design approaches to the German computer science community (Floyd et al 1987). In drawing on cooperative design she and her colleagues combined participatory approaches with traditional systems design (Floyd et al. 1989, Reisin 1992, Falck 1989). This research resulted in socially oriented software development methods. Because of that orientation towards software engineering the existing variety of participatory approaches was strongly interpreted as debate on methods in the German context.

"Softwareergonomie" is another German reformulation of participatory design, which was rooted in the "human factors" research of the 1940ies in the US. Their proponents struggled for models of human-computer interaction, methods for the design of work processes, criteria for the design of dialogue systems and tools for software development. While legal regulations on the ergonomics of computer work places could be achieved, the research finally mainly concentrated on the design of the interface, which primarily focuses on physical and psychological abilities and limits of individuals in human-computer interaction (see e.g. Herczeg 1994). Although these two strands lost the political impetus that the Scandinavian workplace democracy approaches held, they, nevertheless, partly drew the attention to the social – compared to traditional software engineering methods, which were limited to rigid engineering concepts and formal descriptions.

4.2 Debate on disciplinary foundations

On the background of an understanding of computer science as basically rooted in engineering, in science or in mathematics and logic, a second debate evolved toward the end of the 1980ies, which questioned the narrow borders of the technological via approaches that brought in the social sciences. One starting point of that discussion was the report of an ACM-committee on computing curricula that concluded: "The basic question of the science of computing is: What can be efficiently automated? " (Denning et al. 1989) Another prominent role in the debate on the theoretical foundation of the discipline played Edsger W. Dijkstra's (1989) decisive formal-mathematical standpoint. He argued in favour of drawing a sharp line between the 'correctness problem' (based on symbol manipulation) and the 'pleasantness problem' to design a user-friendly interface (based on experiment and psychology). Thus, a

'logical firewall' was supposed to protect computer science from engaging with users' perspectives and in social context. David Parnas (1990), instead, advocated a radical change of the computer science curricula towards an engineering discipline, while Terry Winograd (1989) accused Dijkstra of arguing on the ground of wrong premises. In pointing to the problem of designing software and computer systems he reminded of the fact that technologies are means for precise concerns and applications.

Motivated by these discussions in Germany during the end-1980ies an open interdisciplinary research community of computer scientists, philosophers, work scientists, psychologists and sociologists grew seeking for a theory of the discipline, (cp. Coy et al. 1992). Some approaches regarded computer science essentially as a science of "analysis and (re-)organisation of work processes" (Wolfgang Coy), a science of "machinization of mental work" (Frieder Nake) or a "technology of knowledge" (Friedrich Luft). Nonetheless, an understanding of computer science as "Gestaltungswissenschaft"[2] where "Gestaltung" (design) means a combination of building with interpreting, or of understanding with producing, respectively, constituted the strongest counter movement to the formalist scientific self-conception.[3] Proponents of this approach characterised computing as a design of workplaces instead of design of machines, going along with socio-technical and participatory concerns. They argued that since the products of computer science are strongly intervening into social reality, the discipline would have to clarify its epistemological foundations as well as basic ethical issues.

In searching for a theoretical ground of computer science and bringing in a substantiated social science and humanities reflection of computer scientists' activities, 'Gestaltungswissenschaft' questioned the narrow mathematical-formal and engineering understanding of the discipline fundamentally. Although this critical project gained some attention within the mainstream and resulted, for example, in the establishment of chairs for "computer science and society" at German universities, the far reaching requirements of inter- and transdisciplinarity that the "Gestaltungwissenschaft" approach theoretically claimed have never been fully realized. Instead the rhetoric of a "core of the discipline" became popular, which shifted the socio-technical divide from a disciplinary marker for the inside and outside of computer science to a splitting line across the discipline that separates margin from core.

4.3 Debate on understanding the computer technology

The third debate, which challenged the socio-technical divide in computer science discourses, aimed to understand what was new about the computer technology and its role in use and society. In the German context of computer science this line of research was primarily based on philosophy and social history of technology approaches combined with weak influences by media studies rather than drawing on social science and technology studies, which have become more widespread in other countries.[4] As opposed to the conventional historiography of information technologies that focused on the genealogy of the computer as apparatus, proponents of the new perspective on computing aimed to understand special nature of software and computers compared to traditional technologies. Later on they concentrated on the analysis of software and the computer as a cultural artefact. More than a decade after computers had entered workplaces the topic of socio-cultural change going along with the new technology emerged again, when computers started to pervade everyday life practices during the 1990ies. The emerging use of online and real-time application was to be explained as well as the complexity of networking and technical decentralisation.

2 Much of this research referred to the work of Winograd/ Flores (1986), who in turn interpreted software technology on the basis of philosophical traditions, particularly in drawing on Martin Heidegger.

3 see Wolfgang Coy, Arno Rolf, Dirk Siefkes, Walter Volpert in: Coy et al.(1992)

4 Since the socio-technical divide is one of the main focus of my argumentation, it seems to be important to notice that proponents of this debate by that time did neither draw on contemporary sociological research on technology such as Actor-Network-Theory (e.g.Bruno Latour or John Law) nor did they refer to feminist technoscience studies (e.g. Donna Haraway). Latour's thesis of an anthropological symmetry (Latour 1993), for example, which proposes a concept of agency that includes human and non-human (e.g., technology) actors and thereby dissolves the borderline between the technical and the social, was not mentioned in these discourses.

At the beginning of the debate Sibylle Krämer (1988), for instance, characterized computers as "symbolic machines", which mark a temporary culmination point in the evolution of (formal) languages and of technologies of the mind, whereas Mihai Nadin (1988), amongst others, denoted them as "semiotic machines". Frieder Nake (1997), in the following, referred to Peirce triadic relationship in concluding that software is rather a relationship than an entity ("Ding"). In his view a major part of computing consists of a semiotization that transform things and processes of daily lives into signs. The specific characteristic of the computers should, therefore, not been seen their machine character. Rather they were means to machinize mental work.

Another strong branch of the critical discussion in the German computer science aimed to capture those developments that were in need of explanation by determining scientific metaphors, orientation patterns and "Leitbilder", in which leading questions, images, visions, thinking styles in computer science and their transformations crystallize within a shorter time span than that associated to Kuhn's notion of a scientific paradigm (cp. Hellige 1994, Siefkes et al. 1998). Not only conceptual and theoretical questions had been discussed, the approach also generated fruitful case studies. 5

One of the most popular metaphors in and beyond computer science discourses during the 1990ies was the notion of the computer as medium (e.g. Bolz et al 1994), which was often understood as the fact that computers became technically capable of integrating almost every former medium. As Coy (1995) pointed out new applications (such as e-mail, ISDN, FAX, electronic books, digital photo, radio and TV) transformed computers and computing into a cultural technique. Computers became a relevant part of the socio-cultural transformations processes often described by the terms "information society" and "globalisation" that both call for computer scientists' responsibility and a thorough technology impact assessment. Coy, furthermore, characterized the development of computing by three conflicting, but not necessarily contradicting views: automata, tools and media. Computers abilities to store, record, transport and transmit information, which increasingly displaced its calculation functions, fundamentally challenged the traditional understanding of the computer technology as a machine or tool.

While Coy already considered networking as a prime aspect of the computer as medium, Heidi Schelhowe (1997a) introduced a broader view of that notion in pointing out the opportunities for human-computer interaction and most notably for computer mediated communication. She traced back notions of the media metaphor to the early works of Carl Adam Petri who is well known in the computer science community due to his model of concurrency proposed in his dissertation 1962, today called Petri net. However, his vision of the computer as a medium for communication and social exchange, which was refreshed during the 1990ies with the rise of the Internet, could not win recognition against the - at his time - dominating idea of the computer as a sequential production machine in the tayloristic tradition of Turing machine.

In all of these theoretical efforts to understand computers, software and their novelty, these artefacts were clearly distinguished from traditional technologies. Particularly the notion of the computer as medium referred to a transgression of technological borders towards the social, which now seemed to be continued by the interaction paradigm and the concept of social machines. In giving computers a new meaning nevertheless, the rise of the Internet had a much more striking effect than discourses in the computer science discipline could ever have gained.

5 Reading the debates from feminist perspectives

The tendencies described so far to overcome the socio-technical divide were welcomed.by German feminist computer science researchers. Particularly the most critical positions, which were stated in the three historical discourses, had been a source for the hope that the initiated shifts and transgressions might contribute to changes in the structural-symbolic relationship of gender and technology.

5 Susanne Maaß (1994), for instance, hermeneutically identified roles which common metaphors of human-computer interaction such as machine, system, partner, medium or virtual reality implicitly assign to users and designers, while Jörg Pflüger (1994) decribed the history of programming concepts by the "epistemes" (Foucault) writing, building, growing.

In the debate on software development practices participatory approaches formed a basis for feminist intervention in systems design. Scandinavian and German software projects aiming at an empowerment of women were successful at workplaces dominated by women such as nursing and office work (e.g. Bjerknes/Bratteteig 1987, Vehviläinen 1991, Winker 1995). Female researchers also developed methods for participatory design that aimed to destabilize the gender-coded hierarchy between designers and users.6 Thus, these computer scientists encountered gendered structures of inequality in two ways, on the structural level of labour conditions and on the symbolic level of the existing gender order.

The traditional foundations of computer science that were questioned in the second debate, also gave reason to hope for change, since understanding computer science as a formal discipline (like mathematics), as a science or as engineering – as Grundy (2001) later summarized - perpetuates the myth of objectivity and maintains the dichotomies of the subject and object as well as that of rationality and emotionality, which all have been criticized on the basis of feminist theory.7 Feminist computer scientists argued that understanding computer science as a 'Gestaltungswissenschaft' instead, and opening it up to social science and humanities issues would weaken the strong male connotations of the discipline (cp. Erb 1996). This might, on the one hand, attract more women to the study of computer science. On the other hand, integrating reflections on fundamental questions (e.g. socio-cultural impact of technology, epistemology, ethics) into the curricula opens up the opportunity to discuss gender issues as legitimate subject of the discipline (cp. Schelhowe 1992).

Since mystifications of technology and machine-centeredness were identified as most relevant barriers for women in the field (cp. Erb 1996), a re-symbolization of the computer science discipline and the computer technology played a major role in the discourses of German feminist computer scientists. The efforts continuing on the third debate addressed an understanding of traditional technology, which is due to a strong engineering tradition particularly in Germany linked to images of male engineers and of technical work as heavy bodily labour. While the machine and the tool metaphor for the computer can still be interpreted within this frame, the notion of a medium, however, stresses social-communicative aspects, which symbolically do no longer refer to the masculine engineering realm. Therefore, the new function and use of the computer, most notably computer mediated communication, might dissolve the male coding of the understanding of computer technology (cp. Schelhowe 1997b)8 and thus, in turn, bring in more women into the discipline.

Inner-disciplinary tendencies to overcome the socio-technical divide seemed to be promising from perspectives of feminist research. Since in each of the three debates, however, the borderline between the technical and the social was shifted only to a certain extent, the question arises in how far related feminist visions could have been realized in the long run.

From the angle of (female) users and their work place conditions most participatory design projects, which were initiated by feminist researchers, turned out to be successful enterprises. Several female German software engineering researchers (e.g. Falck 1993, Floyd 1994), however, complained that their scientific achievements had been devalued and excluded, if they had resorted to participatory methods or even worked on feminist projects. So their engagement in emancipatory software development practices turned out to be a rather ambivalent endeavour. Furthermore the object-oriented canon of methods, which has meanwhile become dominant, again focuses on engineering and formal aspects. Although some of the new aspects that have been integrated into current software engineering methods appear as if they were reactions to old critical objections, basically these methods still support the profoundly gendered relationship of technology designers and users on a structural-symbolic level.

Approaches following the second debate, which were critically reflecting on the foundations of the discipline, in Germany could be settled in institutes for "computer science and society" or "applied computer science" during the 1980ies and 1990ies. Though marginalized as compared to the so-called

6 See Martina Hammel (2003) for a summary

7 See Christina Björkman (2005) for a critical review of the international debate on foundations of computer science from a gender studies perspective.

8 Similar arguments were brought forward outside the computer science discipline, which ranged from cyberfeminist positions (e.g. Sadie Plant) to discussions of a possible "feminization" of the Internet.

"core of the discipline" or even reduced nowadays, this kind of institutionalisation smoothened the way for establishing first gender studies chairs in computer science at German universities (e.g. 1998 in Bremen). In spite of this outstanding achievement, critical and feminist voices in the foundation debate have neither been particularly successful in opening up computer science toward the social nor in creating a new - and less male coded - image of the discipline.

In destabilising the traditional understanding of computer technology, which was questioned in the third debate, the Internet played a major part. The consequences of Internet use and its socio-cultural impact, however, did hardly affect the dominant parts of the discipline. To the contrary, aspects of the Internet declared as 'non-technical' have increasingly been separated from computer science, sourced out into other occupations like web design and content management or into new fields of study like 'Medieninformatik' (digital media), while at the same time became symbolically marked as feminine. Nevertheless, labels such as "media" actually seem to contribute to the fact that more women started a study within the computing sciences, while - as Britta Schinzel (2002) pointed out - the prefix of "technical computer science" rather prevents them from entering the field. Although some auspicious trends exist towards a new meaning construction on the fringes of computing, the hope for a new image of the discipline and a new understanding of the computer technology, which transcends male connotations, has not been fulfilled yet.

So far a closer examination of German computer science discourses revealed that feminist approaches were only as partly successful in changing the relationship of gender and computer science or the computer technology, respectively, as traditions of critical thinking have been in overcoming the socio-technical divide. Historic processes simultaneously exhibit conflicting lines which in one of the gender dimensions (identity, structure and symbolism) appears as an achievement from feminist perspective while in the other re-enacts old gendered patterns.

At this point I want to come back to the starting point of my contribution, the current hype on interaction, especially on social machines. How was and how could this trend be evaluated from feminist computer scientists' perspectives? And what can we learn from the history of the three debates examined so far about the mechanisms utilized in computer science at the borderline between the technical and the social, which either encourage or impede changes in the structural-symbolic gender order?

6 The interaction paradigm as a contested zone

"Interaction" evolved - as stated above - to a new paradigm of the discipline, which has also been widely appreciated within the gender studies research. A closer analysis, however, will disclose the variety of facets how feminist and mainstream computer scientists conceptualise the term. Frances Grundy (2001), for instance, argues in favour of a concept of 'interactionism' that distances computing from male-coded objectivity. Interactionism in this sense emphasises the importance of communication and of emotions in use, design and education processes. It calls for (epistemological) pluralism that rejects traditional dichotomies like true/false, subject/object, sender/receiver. Another interpretation is "interactivity" that according to Heidi Schelhowe (2004) refers to meaning construction processes of users in human-computer interaction. "Data, which is not invested with meaning while processes inside the machine, is continuously interpreted by humans, becoming information as a consequence. Humans, 'users', must verify the processing operations for correctness and relevance in a world of human activity, and based on the result, initiate further processing steps, in this way 'communicating' with software." (Schelhowe 2004: 326) Since users have to make sense of software in their real life contexts, Schelhowe claims that concepts of "interactitivity" can no longer be modelled only on the basis of machine-focussed approaches.

In relying on social science and humanities theories Cecile Crutzen suggests to understand "interaction" as an exchange of representation between actors. "Interaction is an ongoing process of mutual actions from several actors in a (series of) situation(s). It is a process of constructing meaning through repeated interpretation and representation of the actors that is always situated in the interaction itself". (Crutzen 2003: 90) As opposed to most computer scientists' views her notion also includes what is missing: "Not

only the actual behavior but also the actions, which are not executed in the interaction (actions in deficient mode), are presentable and interpretable because these absent actions influence the interpretation process, too. Therefore, this exchange of representation is far from being a simple transmission process from a sender to a receiver" (ibid.)

Crutzens notion of interaction is, furthermore, crucially involved in what she terms "transformative critical rooms". These are characterized as those rooms, where actions of questioning and doubt are present, which have the potential to change traditional habits and routines in computer science.

The three positions illustrate that the interaction concepts introduced by feminist scholars all take a critical stance towards traditional computer sciences' concepts.[9] They question and deconstruct basic assumptions of the computer science discipline from feminist and epistemological perspectives in a way that destabilizes the socio-technical divide. While these feminist approaches aim to create new meanings of the interaction paradigm, mainstream computer scientists take rather a technological point of view.

Wegner (1997) notion of interaction, for instance, strives for unifying concept, which captures all the changes, which programming, software architecture, systems design, Artificial Intelligence etc. at his time had undergone.[10] Since the interaction machines he proposed are defined as an extension of the classical Turing machine, his he actually does not leave traditional concepts. Stein, on the other hand, explicitly aims to challenge the outmoded computational metaphor. However, her interaction model is mainly inspired by technology-oriented problems.[11] In the field of "social machines", interaction is primarily construed as a combination of the partner metaphor and the tool metaphor, which refer to the research tradition of AI and of HCI, respectively. Elements of face-to-face communication are formalized in order to implement such reduced models of human interaction into socially intelligent robots and affective embodied conversational agents.

Hence, the different notions of the interaction metaphor in mainstream computer science obviously catch crucial changes in computing that already occurred. In contrast to a critical feminist understanding of interaction, which strives for overcoming the borderline between the technical and social, however, the focus and reference of these interpretations is rather limited to the technology side of the socio-technical divide. The controversial lines of argumentation, nevertheless, demonstrate that the meaning construction of "interaction" in computer science is nowadays a contested zone–with regard to the socio-technical divide as well as to its structural-symbolic entanglement with the gender category.

7 Conclusion

From history we have learned that shifts in the socio-technical divide did not always succeed nor do they automatically bring changes to the existing structural-symbolic gender order. However, at the same time we have seen that precisely these shifts have the potential to open up space for feminist perspectives within the computer science discipline. Since the socio-technical divide is at present re-negotiated by the new interaction concepts and since social machines are still 'technologies in the making', the question arises, which changes the latest debate might bring.

The analysis of the three debates in the German computer science discipline provides several controversial scenarios how the gender-technology relationship could be affected by recent developments. One of the open questions is whether it is possible to intervene into these processes of technology design from a feminist perspective. Here, the example of participatory design indicates that critical approaches can certainly be successful in changing the software development practices, in regard to local contexts of the applications as well as to methodology. If these positive experiences were transferable to the new interaction paradigm, feminist approaches would contribute to overcome the outmoded epistemological concepts of a general truth, objectivity and of traditional dichotomies like subject-object in computer

9 A critical attitude is not a new move in the domain. Lucy Suchman (1994), for instance, questioned the basic assumptions, on which Winograd and Flores built their famous CSCW-application the COORDINATOR. Her criticism of using concepts of planned (inter)action based on Searle's speech act theory in systems design initiated a heated debate in the CSCW-community.

10 Such as objects-oriented programming, agent-oriented artificial intelligence or embedded systems.

11 E.g. How can system designers learn to think concurrently? How can robots interact with the physical world?

science. They would contribute to an understanding of truth as particular and situated, turning the attention to meaning construction processes in human-computer interaction.

A second way to think about the future perspectives is in terms of institutionalization processes at universities. The retrospection of the debate on the foundations has shown that critical as well as gender approaches could have been established as a legitimate subject inside the computer science discipline. If computing would refer to interaction as a key paradigm, social science and humanities approaches will have to be integrated in the discipline even more foundational than today. Hence, a new self-concept of computer science, thereby, also bears the potential that gender research and feminist studies inside the discipline will gain recognition and thereby become less marginalized.

A third dimension of interest is the question of gender equality in terms of participation. Especially in the field of anthropomorphic software agents we can already observe that a remarkably large number of researchers is female compared to other areas of AI or computing.[12] A similar effect was found, as mentioned above, when digital media emerged as a special kind of the computing studies. Thus, shifting the center of computer science towards interaction, which emphasizes the social aspects compared to technological parts, might increase the participation of women.

That leads to the forth dimension of future prospects, the potential of the interaction paradigm to bring more profound change the gendering of computer science and the computer technology on an structural-symbolic level. The three debates mentioned, however, indicate that a new and less gendered image of the discipline or the computer technology seems to be rather questionable.

Although the new paradigm of interaction promises change in the gender-technology relationship a critical re-reading of the historical discourses in German computer science also warns of regressive forces. The - apart from a few positive examples - still missing success of critical and feminist approaches to disburden computer science from male connotations, for instance, draws the attention to counter movements. In the three debates considered here, 'useful' elements of critical or feminist approaches were integrated into the mainstream while those aspects, which have the potential to question the mystification of technology and of formal engineering, were carefully kept out of the discipline. The marginalization of participatory and feminist approaches with an inherent political claim, the rhetorical construction of a "core of computer science" against a tolerated periphery, and the separation of technical aspects from socio-cultural significance in recognizing the new media character of the computer are mechanisms which turned out to be effective barriers to overcome the socio-technical divide and to change the gender-technology relation. Marginalization, separation and devaluing also might be applied as powerful strategies in the current struggle on meaning constructions of the interaction metaphor.

Interaction is a contested zone, which may be exploited or may allow for doubt and critical positioning. It is the arena where the socio-technical divide is negotiated today. If critical approaches take the counter movements mentioned seriously, while at the same time strive for a meaning construction of interaction as proposed by feminist computer scientists, the foundations of computer science as well as in the societal images of the discipline and the computer technology might change fundamentally. In the light of the historic debates within the German computer science discipline the new interaction paradigm calls for an extensive and radical intervention on the base of a political and feminist understanding.

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12 For instance, in the preface of a book that resulted from a workshop on multicultural believable agent, Sabine Payr and Robert Trappl state: "After searching the literature for potential participants, we found, to our own – positive – surprise, that nearly all scientists who considered this aspect in their work were women, therefore a vast majority of the participants were female" (Payr/Trappl 2004: x). See also de Rosis (2001)

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