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Gender and Network Awareness in/for successful leadership in academic Science and Engineering

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ABSTRACT
This paper focuses on gender and network awareness and their importance for academic leadership positions in Science, Engineering and Technology (SET). Empirical material stems from a German study (2009 to 2012) which focussed on the potential for innovation among women in leadership positions and the barriers they experience. The basis is a qualitative study with case studies in different organisations, a technical university and different research institutes from one big governmental research organisation. Semi-structured interviews and focus group discussions with female and male professors are the empirical basis for results. Research questions focus on effects of gender awareness on women professors' strategic responses, different responses of individuals to inequalities when they become more network aware, and the importance of both gender and network awareness to counter inequalities. Gender aware female professors are more successful in individual coping strategies (handling visibility, fighting for acceptance and against discrimination, solidarity and support of women). Gender aware organisational cultures are evident in mentoring programs and equal opportunity policies. Interviewed professors show an overall high networking awareness. They are convinced that successful leadership in a technical field requires inclusion in internal and external networks, especially for information, cooperation and projects. Women in SET need to be gender and network aware to overcome hindrances stemming from their limited participation in powerful informal men's networks.

KEYWORDS
Gender awareness, network awareness, informal men's networks and gendered exclusion, gender in academia

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INTRODUCTION AND SELECTED STATE OF THE ART

In academia gender and network awareness have traditionally been tabooed (Sagebiel 2015) because biases stemming from gender stereotypes and informal networking are not considered to exist in an environment characterized by scientific norms of objectivity, neutrality and choosing truth. Gender and network awareness are two important conditions for successful leadership especially for women in science and engineering. Both kinds of awareness can help female professors to fight successfully against career hindrances.

Networks have gained a central importance in actual societal diagnosis (Castells 2001) as a reaction to increasing individualization (Beck 1986) and isolation (Sennett 2006). In academic careers, experience of 'entgrenzte Arbeit' (academic work with fluid boundaries to private life) has been analysed as a necessary commitment to scientific work (Beaufaÿs 2015, Metz-Göckel 2018). This permanent workload and stress could induce depression (Ehrenberg 2008, after Alleweldt 2013), 'enclosure of me' (Illouz 2011) and estrangement (Jurczyk & Voß 1995). To counterbalance these developments, networks are necessary but separation between private and professional ones can become blurred (Boltanski & Chiapello 2001). Granovetter (1973) has distinguished between strong and weak ties to characterize the quality of networks for professional careers.

The thesis of this paper is that networks and network awareness influence the success of women as well as men in leading positions. Male researchers in engineering, even without leadership positions, know about the importance and necessity of networks for their everyday work, while female researchers in similar positions assume networking to be time consuming (time they do not have) and as not belonging to their everyday work content (Sagebiel 2013b). Moore & White (2001: 148) found in their quantitative international comparative study that "the formal position is the most important factor for the scope and amount of contacts" (translation by the author). So, people in higher positions engage in a bigger number of more complex networks and so should be more network aware. Social capital (here in the meaning of rich networks) for successful upward mobility increases with higher career levels (Scheidegger & Osterloh 2004: 514).

Gender awareness is necessary for reflecting gender stereotypes, which can create bias in science and higher education. Women are aware that they are a minority in SET and often they have experienced discrimination in one way or another in their educational and professional career. That does not necessarily mean the same as gender awareness, which requires reflection on gendered structural discrimination in a male domain like SET. They also can deny gender differences in the field, which means that they are not gender aware. In contrast, male scientists and engineers being the majority group, often see gender as being not a problem (Sagebiel 2013a) or only a problem when a female colleague comes along; so, only a

minority of male leaders in academic SET analyse structural gendered interconnections in SET and thus become gender aware.

In leading positions, gender inequality still exists in all disciplines and areas. Throughout the European Union, gender segregation in SET starts in school, continuing in choice of degree courses and subsequent career levels. Only 32% of scientists and engineers are women (EC 2013: 5). While the number of female PhD graduates in total is now nearly equal to men, in engineering they are still significantly underrepresented (26%). In terms of career progression, in science and engineering, the attrition of women increases at post-doctoral level and improvement over time is small and slow (EC 2013: 89). It is, therefore, not surprising that in the fields of engineering only 7.9% of women hold full professorships (EC 2013: 6). Moreover, there is a gender gap in scientific output in Europe (EC 2016: 91). "In recent years, women in the EU-28 are significantly under-represented in research and innovation outputs. This under-representation is more severe in 'innovation' (patent applications for inventions) than in 'research' (scientific publications)" (EC 2016: 90).

In Germany, the natural sciences and engineering remain bastions of male domination (EC 2013: 62). But the glass ceiling as a barrier is less in some SET disciplines which have the smallest proportion of women (Matthies & Zimmermann 2010), such as mechanical and electrical engineering, computer science and physics (for the latter see Langfeldt & Mischau 2018). This means that the percentage of females is not declining as much on the next career level. To understand gender differences in SET this paper will refer to the following research fields:

- Gender stereotypes of leadership and gendered stereotypes of technology
- The role of networks and gender in the construction of excellence and merit
- Gender awareness in men's networks.

Gender stereotypes of leadership and gendered stereotypes of technology

Generally, the homo-social culture of senior management is a barrier for the recruitment of women to top positions. The informal management culture is characterised by 'male bonding' and communitarianism, which is characterised by rituals of strong hierarchies, self-verifying of equality, and prohibition of fraternization (Rastetter 1998). Men learn basic skills for management from their youth onward in their 'serious competitive matches'. "*This masculinity has a competitive structure learned in homo-social fields which young boys train in risky competitive play"* (Meuser 2006: 164, with reference to Bourdieu, translated by the author). Gender-based organization studies have demonstrated the formal and informal ways in which organizations are gendered (Acker 1990; Wilz 2004; Wimbauer 1999). Stereotyped gender roles, myths of equality and the masculine organizational culture, which define the ideal manager, hinder career chances of women (Matthies et al. 2001; Matthies 2005).

Wajcman (1998: 63) in her analysis of several studies on management styles found numerous gender stereotypes regarding leadership. Wajcman argues, on the basis of her research in management as a man's field, that women have to adapt (Wajcman 1998). Evetts (1997) formulates how ambivalent this adaption of women

in management positions can be because gender expectations are in conflict with managerial responsibilities*:*

> *"if the woman is an efficient, competent manager, she is likely to be judged as 'unfeminine', but if she demonstrates the supposedly female qualities of care and sensitivity she is likely to be assessed either as an inappropriate and inefficient manager (Kanter, 1977; Marshall, 1984) or as a good female manager"* (Evetts 1997: 229).

For women leaders to overcome this binary thinking, combined with the devaluation of women as the weaker, two coping strategies are available, that they play the game or else that the existing culture accepts different truths (Knights & Kerfoot 2004: 432). Gender stereotypes together with the gendered stereotypes of technology (Faulkner 2001; Sagebiel 2010; Vázquez 2013; Wajcman 1996) have their origin in universal dualistic thinking (Faulkner 2000; Wajcman 1996) and play an important role for reproduction of gender stereotypes and segregation. Even top academic women meet those gender stereotypes embedded in a binary system (Sagebiel 2013 a). Wajcman (1996) argues that because of segregated thinking the female identity construction would be in conflict while the male identity construction would be in harmony with technology. Gender and technology stereotypes may be applied to reinforce the exclusion of women as outsiders based on their perceived 'otherness'. This devaluing stereotyping for women engineers results often in a fragile self-confidence (Erb 1996; Håpnes & Rasmussen 1991).

Men's domains (Kanter 1993) like SET and management are characterised by structural characteristics like marginalizing minorities (women) and men's (informal) networks and bonding. In a male domain like engineering the coping strategies of women are: *"acting like one of the boys, accepting gender discrimination, achieving a reputation, and seeing more advantages than disadvantages" (*Powell et al., 2009: 425).

The role of networks and gender in the construction of excellence and merit

Networks and gatekeepers have a great influence on construction of excellence, a prerequisite for getting a professorship in academia. *"The definition and assessment of scientific excellence (the recognition of merit) is not independent of gender relations in academia and society at large"* (EC 2012: 18). The so called 'co-optation principle' (Krais 2010: 23) based on gatekeepers and networks which stems from the organisation of higher education in Germany is important for obtaining a first professorship. Networks play a central role for getting access to research funding and publication opportunities as prerequisites for excellence and for promotion to academic positions (Van den Brink 2010; Van den Brink & Benschop 2012). Even in formal assessment procedures, networking leads to unequal chances for women (Sagebiel 2015). Women are disadvantaged because they cannot rely upon the help of their mentors and networks as much as men can (Metz-Göckel 2018; Salminen et al. 2018; Van den Brink 2010; Van den Brink & Benschop 2012; Wolffram 2018). The belief, that scientific excellence is based only on qualification and performance, stems from the gender-based ideology of

meritocracy. Getting ahead does not result solely from individual merit, because this idea ignores the informal support system that exists among men (Bagilhole & Goode 2001; Beaufaÿs 2015; Beaufaÿs & Krais 2005; Gross & Jungbauer-Gans 2007; Gruhlich & Riegraf 2016; Husu 2005; Krais 2010; Metz-Göckel 1999; Morley 1999 and Sagebiel 2010 a, b).

Social factors have seldom been considered in science research; gender especially has been neglected (Krais 2000; 2010). Nevertheless, most career theories proposed by writers such as Weber, Giddens, Kohli and Sennett do not integrate the private sphere and rely on male employment concepts (Schiffbänker 2009). Women have been recognised within the scientific community less than men because they have been defined as outsiders, as 'someone strange' (Beaufaÿs and Krais 2005 with reference to Bourdieu 1997) which creates an (in)visibility dilemma for women. Women as a minority in science higher hierarchical levels are highly visible as women but less visible as scientists, and the same is true for female engineers in academia (Faulkner 2005).

Having children is another barrier for women in academia. Especially during their early careers women experience disproportionate disadvantages because of conflicts between family and career demands in research. Even female scientists without children are affected by the expectation that they could have children and so get less promotion by networks.

> *"Many studies show that the family-or-science dilemma is not only gendered, but exacerbated by institutional constraints and implicit academic norms, values and expectations that take the traditional male life-course as the norm"* (EC 2012: 17).

Women's slight disadvantages during the early stages of their scholarly careers might add to (dis)advantages in their subsequent career outcomes (EC 2012; Faulkner 2005). Defined gender differences (gender stereotypes) and men's networks have consistently been deployed to manipulate and weaken women's chances for a successful career and work (Wajcman 1996; Knights & Kerfoot 2004).

Gender Awareness in (men's) networks

Networks are important for academic leadership in engineering research because they are part of the definition processes of excellence: Networks and gatekeepers determine career criteria like excellence of research projects and publications. This holds true for formal networks like scientific associations and their committees as well as for less transparent, and at the same time more important, informal networks (Sagebiel 2015).

Networks in general management (Burt 1998; Funken et al. 2011; Ibarra 1997) and in engineering research are gendered (Sagebiel 2010 a, b). Homo-social men's networks demonstrate their exclusiveness through selective processes for new members, restriction of information, secrets and strict separation of members and non-members (Rastetter 1998). Especially, powerful networks in management are structured as 'Maennerbuende' or male-bonding (Rastetter 1998). They function

with their norms of all-time-availability, informal structural information channels, hierarchies and mechanisms of exclusion (Doppler 2005; Rastetter 1998). Exclusion structures are one of the most important mechanisms for the perpetuation of low numbers of women in top positions and in internal processes for exclusion from information. More women scientists in leading positions imply more direct competition with men on the same level. Men fearing this threat from women strengthen informal activities in networking excluding women (Miller 2002; Ohlendiek 2003).

Women's networks have manifold positive functions for information, communicative exchange, solidarity etc. (Metz-Göckel 2016). The low number of women in engineering workplaces reduces possibilities of direct cooperation and networking among women. Women's lesser integration in men's informal networks (Sagebiel 2010 b; 2014; Sagebiel & Dahmen 2008; 2006) cannot be compensated by women's mostly formal networks which have less inner organizational power. Moreover, according to Rothstein and Davey (1995), women and men in management positions use different networks, but both include more men than women. Women's networks have less status and power. Both men and women get as much support, but women must contact more hierarchical levels[1]. Ibarra (1997) found that high potential women in industry showed a gender as well as a network awareness. They follow the principle of homophily and use women's networks for getting information to a higher degree than non-high/lower potential women and even high potential men. Moreover, these high potential women had more strong ties (Granovetter 1973) among each other in the networks, which would not be positive for high potential men because for them weak ties in their networks are better (Ibarra 1997: 99).

Power relations are interrelated with the masculine culture of men's networks together with the male power play of competition and cooperation. In the natural sciences, there exists a gendered competitive style with men fighting for positions in a (male) hierarchy. As Etzkowitz et al. (2000: 115) state a strong interconnection exists between successful scientific cooperation, networking and output (so called Kula ring). To strengthen network connections, one has to learn to demonstrate one's attractiveness as well as value the qualifications of the partners for cooperation and competition.

In the homosocial culture of men's networks, women are perceived as not fitting in (Rastetter 1998: 173; Sagebiel, 2014; Zimmermann 2000). McPherson, Smith-Lovin & Cook (2001) have focused on the importance of the similarity principle for people to network. Top women in research are aware of the male 'homophily' in spreading network resources (Kegen, 2016: 51; Sagebiel, 2016). Women - as 'others' being different, not male - cannot be trusted. Trust in men's view functions to reduce social complexity especially in informal situations (Tacke, 2008: 267). Since trust seems to be a prerequisite for choosing network partners (Deters, 1995; Vaske & Schweer, 2013), women are automatically discriminated in this process of integrating in men's networks.

This informal discrimination against women is what Gail M. McGuire also found in her research: *"Women may have been perceived by network members as poor or risky investments because of cultural beliefs that ranked them below that of a white man according to status characteristics theory* (2002: 316). Against these excluding working cultures which use fitting in as selection criteria, nothing seems to be effective, because even high-status women seem to be a "risky" investment, on either a consciousness-raising or an ethical level. This is also true for women leaders who have the same position as men (McGuire 2002: 304). Burt (1998) found that men's networks, which have been good for their career, are not as beneficial for women because of the lack of legitimacy of women in management positions. He thinks that for women it is better to borrow strategic male partners from outranked positions to gain social capital. Equal opportunity politics seem helpless against these informal gendered career barriers because vested informal men's networks can easily undermine them (Sagebiel 2007:155).

Analyses of gendered careers in higher education can be supported by Connell's concept of hegemonic masculinity (Connell 1999). Polarized gender stereotypes help to reproduce the hegemonic masculine ideal, particularly in leadership positions, and help to reproduce masculine values and norms of traditional organizational culture (Höyng & Lange 2004, Sagebiel 2007: 150). The concept of patriarchal dividend (Connell 1999) for only those who belong to the male gender biases the competition. Whether new masculinities will modernize management to be more women friendly is an empirical question. According to Lange (1998), it is not very likely that the higher value of soft skills, traditionally defined as female, will result in higher valuing of women.

On the basis of the research presented, the paper focuses primarily on the following main research questions: Is better awareness of gender biases associated with different strategic responses among women professors? Do individuals respond to inequalities in the institution differently when they become more network aware? Why is it important to be both gender and network aware, does it afford advantages or the means to counter inequalities?

The paper analyses a selection of results from an empirical project[2] (lasting from 2009 to 2012). It focuses on gender and network awareness, based on two cases, in which female and male professors were asked if and how women engineers in top management can change organisational culture to be more gender equal. The project analysed the role of networks and networking for successful change, as well as gendered promoters and barriers. The research questions above will be analysed by selected results. A gender difference perspective has been selected as appropriate to explore the issue of successful academic leadership, taking gender in account.

METHODOLOGY

Data taken from a bigger German study focus on the potential of women's innovations at the top of different kinds of organisations: industry, academic, political and research. The study was financed by the state Ministry of Education and Research in the framework of a research program 'Women to the top'. For this

paper one technical university in the north-eastern part of Germany and seven institutes of a governmental research organization spread across different regions of Germany have been studied. Both organizations should (at least theoretically) employ representative numbers of women engineers in leadership positions. This pre-condition was particularly necessary for selecting research institutes, because many of them in fact had either no or too few women engineers to ask them for participation in focus discussion groups. Equal opportunity officers helped in selecting interviewees.

The methodological instruments were guided interviews, website analysis and focus discussion groups. In each selected organization, three women in leadership positions and two men in similar positions were interviewed with partly structured guidelines. Key personnel from human resources and equal opportunity offices were also interviewed. The analysis of interviews was structured by the main research questions (see above) and more detailed ones: In which ways does gender awareness help to cope with gender stereotypes about leadership positions? Do gender aware academic women leaders promote other women? How do networks influence definitions of excellence? What role does gender and network awareness play in acceptance in a leadership role? Does gender and network awareness of exclusion from men's networks help to manage cooperation and competition in research? Do women and men in SET leadership positions tell different stories about their mentoring experience? Is there a gendered use of networks for information and cooperation? Does network aware equal opportunity politics help to fight informal men's networks?

In each organization investigated, besides individualised interviews, two gender-separated focus discussion groups with female and male professors (taken as women and men in leadership positions who were not interviewed individually) were carried out. The focus group discussion should facilitate exchange in gender separated groups (Bohnsack, Przyborski & Schäffer 2006). Issues arising were attitudes on gender, success conditions and networking. Otherwise tabooed issues (for instance hidden issues from informal networks) were also touched on. In the technical university and the governmental research institutes, in total 22 participants took part in four focus discussion groups.

The interviews lasted between one and a half and two hours, and were audio recorded and transcribed. The focus discussion groups lasted two hours and were audio recorded and analysed according to the six themes included (gendered leadership, change potential in leadership positions, promoters and barriers, use of networks, gender sensitivity, and power and change potential). Data was collected between 2010 and 2011.

Limitations of the qualitative approach focusing on case studies is a lack of generalization; limitation of the interview methods is that these methods cannot produce nonreactive data – data not influenced by subjective opinions of interviewees.

GENDER AWARENESS IN ACADEMIC SET

Gender awareness could be observed in individual coping strategies of women (handling visibility, fighting for acceptance and against discrimination, solidarity with and support of women) but also in organisational cultures (mentoring programs and equal opportunity's measures for organisational change).

Gender Awareness Helps Women to Cope with Experience of Gender Stereotypes about their Leadership Position

Do women professors experience the prejudice that they are not suitable for leadership roles? One female interviewee stated that she was not accepted at the beginning:

> *"And I have the feeling that people thought they had an easy task to handle a woman who would subordinate herself, and who would agree to everything and cause no problems… This was a fight, which I had to take on. I wanted to change the situation."* (Female university professor and leader in an institute of a governmental research organisation)

Another woman mentioned a similar experience:

> *"Their being able to perceive me objectively as a fellow scholar has only now begun. At the initial stage, I had to work hard to assert myself… because I was invisible. And there have been situations which have been beyond the pale… they would not have dared with a man."* (Female professor in a technical university)

In order to be accepted, these two women had to struggle more than a man would have had to do in order to get acceptance in his leadership position (Hendrix & Sagebiel 2014). Their gender awareness helped to cope with the situation.
A male professor remembers that at the beginning of his professorship he felt accepted even though there was a change in hierarchical order between former colleagues on the same level. Once accepted, he did not have to fight.

> *"I felt accepted, not liked… but at least properly accepted. This was not so simple with me because I had been… here before. This meant that I already knew people from several years before for whom I was now the boss, but this situation worked out very well, although it was not originally clear how it would work out."* (Male university professor and leader in an institute of a governmental research organisation)

One indicator for gender awareness in leadership positions can be seen in the continuity-discontinuity difference of men and women. There is a special gender difference at the starting point of their leadership position as professors. Whereas female interviewees pointed out a different leadership style in comparison to their male predecessor, a male colleague for his own part felt that he followed his predecessors in leadership style. From his former chiefs and supervisors, he had

learnt the principle of hierarchy and delegation with which one can manage a bigger unit, because

> *"I experienced how much more you can do if you are ready to separate a bit from scientific daily duties."* (Male university professor and leader of an institute in a governmental research organisation)

What does it mean when female interviewees relate that they are focusing on a managerial style that differs from that of their male predecessors? One female interviewee stated:

> *"My predecessor concentrated all around himself. He made acquisition for himself and gave the projects to his employees afterwards. This is probably the reason why the working group remained relatively small, which has been manageable for one person with 40 people. This is manageable for one person, but to create an institute means 100 people, means a changing process for the whole team."* (Female professor in a technical university)

In this example, the female professor wanted to expand her research institute, and, to this end, she changed the team's work and organization. By including employees in project acquisition, she delegated responsibility to researchers to enhance their work. She explained that she did her job differently from her male predecessor, by focusing on being 'the best', showing a competitive attitude normally expected from leading men (the 'alpha male' syndrome). Nevertheless, even though she performed her job differently from her predecessor, she did not necessarily do so in what is often perceived as a 'woman's way'.

Actually, both descriptions of leadership style are similar, even though the female leader explains her management style in terms of distance to her male predecessor, whereas the male leader follows his male predecessors. For their aim of managing a large unit, both stress the delegation principle. For the female professor, the delegation of project acquisition to the researchers is an innovation to be re-enforced, all the while overcoming resistance to changes while the male professor follows the structure already in place. In order to achieve the same results, the woman had to be more assertive and put in more energy.
The results show two different aspects of expectations toward female and male persons in SET leadership positions; first male acceptance from the beginning versus necessary fight of female for acceptance and second male continuity versus female discontinuity.

Gender awareness helps women leaders in discontinued situations to cope more effectively with resistance against their leadership strategies.

Gender Aware Women in a SET Academic Leadership Positions Support Other Women in their Careers

Gender awareness in an academic organization measures the possibilities for gender equal decisions. Female professors who were interviewed perceived their

exceptional situation in science and engineering due to high visibility as women. Even though they had experienced discrimination, not all of them support other women to further their careers.
One female professor said that today she is more relaxed in discriminating situations and tries to support careers of scientific junior staff, male and female, but talks about the resistance of women who don't want to undertake responsibility, "they have no interest in leadership functions."

Explicit career support for female engineers has been stated by only one of the female professors in the technical university. In her mind, based on her feminist belief, gender is a horizontal mainstream issue of engineering as a discipline and it is not a subjective niche issue. She wants to sensitize students for gender awareness, establishing gender competence as a qualification:

> *"…this issue gender-mainstreaming … From my point of view professors and scientific staff have understood this. Who did not understand it at all were the students. When we talk about this issue during lessons and seminars …there is always a murmuring. The young men are worse than the old ones! When I am there I tell them that they will not laugh in the future, because they will realize how important gender will be for themselves. When they don't know about this issue they will not step in a career in research, industry and university …"* (Female professor in a technical university)

This female engineering professor definitely focuses on integrating this gender perspective in her teaching as well as in her research. She warns her students against laughing at gender issues because taking account of gender issues is career relevant. She shows the strength of her feminist view and introduces it as a cultural value and norm. This female academic leader not only practices gender awareness but also acts in favour of other women. Moreover, she used her explicit feminist awareness in her strategies, something other female professors did not recognize with this clarity.

One male professor wants to/would prefer women as institute leaders. He thinks they are more stress resistant because of their minority experiences. On the other hand, he feels himself somehow under pressure from his male colleagues and researchers who think differently and so he would have to justify those decisions to male colleagues. His argument is the male dominance in his field and his own weakness.

In another example, a male professor in chemistry in the technical university talks about his learning process of gender awareness due to the work of the equal opportunity officer. Therefore, he supports female employees with family duties during their qualification phase; however, he thinks (at the same time) that postdoc female chemists could not go further in their academic career because they would not be strong enough.

Gender Awareness of Women in Academic SET, Who Realise Men's Power Game as Central Masculinity Culture, Can Handle Power Situations Strategically

Regarding their leadership positions, it is interesting how female professors think about and handle power. Most of the interviewed female professors did not feel ambivalence about handling of power. Most of them said that they wanted power to influence and shape existing structures, to change work details, organizational culture and, last but not least, to set their own agenda as professors. At the same time, several female interviewees rejected power as such in a self-serving sense, seeing this behaviour as typically male from which they wanted explicitly to distance themselves. Power politics are mostly male connoted whereas top women in research do not like to play (Kegen 2016: 50). A female professor focused on gender difference in the following way:

> *"I think women handle things differently. I think that this feeling of having power, with which I am confronted most of the time, is always about male power. Men want power. This can manifest itself in power over people or over a budget, but power is always the first priority."* (Female professor in a technical university)

This woman's view of men's relationship to power reflects her gender awareness of the dominant pattern of hegemonic masculinity reflecting perhaps also her experiences in engineering workplace culture. This was not unique, and all the other interviewed women wanted to distance themselves from this pattern. In their own minds, they wanted power, to be sure, but they explained that they wanted it for different purposes than those motivating male engineers.

NETWORK AWARENESS OF MALE AND FEMALE PROFESSORS

To achieve success in an academic career, networking is necessary. Getting the right information at the right time in the right place is one of the main challenges of a leadership position. For women professors in SET, the strategic handling of information is one of the most important prerequisites. For this reason, women professors must be aware that networks are indispensable in performing several functions:

- for developing an academic career in a technical field (for becoming excellent researcher);
- for acquiring information on time;
- for cooperation in research projects (securing funding for research projects), and
- for recruiting qualified staff members.

Network Awareness as Social Capital Helps an Academic Career

Networks act as social capital for getting information and cooperation but can also function with exclusion of 'others'. Women use mostly formal women's networks and mentoring for learning and organizing networking. Female and male

interviewees appreciated networking as an integrated and necessary part of their work (Sagebiel 2014; Schrettenbrunner, Sagebiel & Hendrix 2012). Female professors in SET are aware of the importance of informal networking/networks and perceive their partial exclusion from those mostly informal men's networks. Scientific excellence as prerequisite for getting a professorship is socially constructed and informal and non-transparent networks play an important role in these processes.

In Germany, qualifying for a professorship entails various complicated selection processes. One female professor from the university precisely described critical points during a search process where networks and networking come into play. Largely hidden, their influence is enormous, virtually replacing objective criteria such as qualifications and performance. Collusive behaviour is central in this field and the understanding and handling of power, which somehow separates men and women in their career.

In her talk about definition of academic excellence during an assessment process for professorship a female professor demonstrates her gender and network awareness as well as the role of men's networks:

> *" Much is functioning via selection processes. Who will be selected as the evaluator? How the list will be constructed...We always think that these processes are fair, but that is not true…I would be naive to think that this story…did not function via collusive behaviour ... Yes, and when you look who got the first place and if one investigates the story afterwards then you will find the connections which caused the result…"* (Female professor in a technical university)

Tacit knowledge is exchanged in this hidden process (Sagebiel 2015; Van den Brink 2010), especially when a particular person should be promoted. By using those partly non-transparent networks, scientific excellence becomes gender biased. Informal men's networks, especially, have a powerful role and increase men's social capital in SET and upper hierarchical levels. Male interviewees are aware of powerful informal structures:

> *"My theory is that men are often in top positions because they are active in different networks and have more connections… Most of the decisions are informally made over a beer, and become formal afterwards…"* (Male university professor and leader of an institute in a governmental research organisation)

This informal beer culture (Rastetter & Cornils 2012: 53; Schrettenbrunner, Sagebiel & Hendrix 2012) strengthens the power of informal women-excluding networks (Wajcman 1996; Faulkner 2005, 2000; McLean et al. 1996, Sagebiel 2014, 2010 a) and at the same time reproduces gender stereotypes in this technical field and dominant masculinity (Connell 1999).

Network Awareness is a Prerequisite for Getting Information for a Leadership Position

For information, especially in leadership positions, internal organizational and informal networks are necessary, as one male leader stated:

> *"One has to have own networks, you have to have your contact persons, certain people who inform you. If you don't have those informants, you cannot work in a leadership position."* (Male leader in a city administration)

This statement focusses on communication as a necessary instrument for getting information. For women in the same position, communications are partly taken as an instrument for exchanging ideas and improving transparency and, at the same time, to transfer decision-making by delegating tasks and, thereby responsibility (Sagebiel 2014: 290). This communicative strategy can be seen as 'relational work' (Fletcher 1999), and as a leadership instrument. An alternative understanding would be that women in leadership positions, especially in male domains like engineering, are missing information due to a lack of network integration as social capital and therefore practice a different communication style to become successful leaders. So, network awareness (of a woman) cannot be evaluated and understood without considering the context of a gendered organizational environment.

Network Awareness is a Necessary Condition for Research Cooperation

A special aspect of leadership as a professor is the high valued competency of successfully managing cooperation and competition. One male interviewee refers to the interdependent relationship between cooperation and competition for acquisition of projects:

> **"***Competition is a condition for cooperation: one can only cooperate with people with whom one has overlapping topics… The idea is that we are not the only ones who are clever, but we try to be the spider in the net where others will come and give their ideas and we help to exploit them."* (Male university professor and leader of an institute in a governmental research organisation)

In this view, competition has a positive effect on efficiency of research, which female professors acknowledge when they talk about competition for projects as normal every day work. Cooperation between men often starts informally, like networking (Etzkowitz, Kemelgor & Uzzi 2000: 115), and competition is biased by men's networks and bonding, often combined with informal exclusion of women. If direct competition between women and men on the same level is existent, informal activities will enhance this in men's networks (Ohlendiek 2003; Miller 2002). Management of cooperation and competition is a genuine male game (Evetts 1997) to which leading female professors adapt more or less successfully (Wajcman 1998), but often without fun.

All female interviewees said that competition and recognition are intertwined, and recognition could only be attained after fighting with a competitor (Sagebiel 2013 a). Female professors adapt to this situation differently. One interviewee expects negative criticism all the time because of negative experience with competition and less support, while one other female professor practices an active way of handling competing situations because otherwise she would expect to be not recognized. The third definitely prefers open instead of hidden competition, viewing competition like a sport with rules. Her only problem is that everyone expects women to be always kind and charming. Her strategy is to be kind, but at the same time consequently oriented towards her issue, which is non-charming in the end. Network awareness helps one to compete successfully in SET research.

COMBINED GENDER AND NETWORK AWARENESS

Gender and Network Awareness Help Women Perception of Exclusion from Informal Men's Networks and Help them to React Strategically

Women in management positions (Ibarra 1992; McGuire 2002) and academia (Van den Brink 2010; Zimmermann 2000) are evaluated as not fitting in men's networks. In SET space, time, media and activities separate them from networking with men (restrooms, meeting at unpredictable times, phoning, drinking at night, doing extreme sports). They realise the barrier, especially when men are drinking at night and they partly do not want to join a network from which they feel not belonging to or exclusion:

> *" I believe that many great deals are still [made] on a men's level … while drinking beer at the bar – I don't do that, I don't drink. … even with my partners in Japan, … what my male colleagues do. And I am very convinced – that may be strange – that I simply meet a barrier … I believe that this being together from man to man would open some door additionally. "(*Female university professor and leader in an institute of a governmental research organisation)

This quote of a female professor demonstrates her gender as well as network awareness and her awareness of exclusion. A male professor in SET mentioned the beer culture as network ritual:

> *"…and one cannot underestimate the importance of this beer culture where men function in a more skilful and more integrated manner than women."* (Male university professor and leader of an institute in a governmental research organisation)

He emphasized the importance of informal networking between men where women are not as well integrated, but it sounds as if he thinks that this would be the women's fault. Instead, less trust towards women explains their exclusion from men's networks (Deters 1995; Vaske & Schweer 2013). Informality together with drinking alcohol implicate women-excluding working cultures. Most women professors are aware of this informal men's networking culture as one of them insists strongly on the collusive behaviour as central. Gender and network

awareness helps women to recognize the structure of discrimination and not to attribute this individually.

Gender and Network Awareness are Necessary to Appreciate the Value of Women's Networks

Women's networks mean social capital (Metz-Göckel 2016: 134) connected with relative power and successfully promoting academic careers. There are formal women's engineering networks, mostly as sections of a large, general, male network. In Germany, for instance the Association of German Engineers (VDI) has such a women's section. In addition, several formal women's engineering networks exist, such as the German Association of Women Engineers (DIB) or the FINUT (Women in Science and Technology). Power and influence of these women's networks is probably not extensive for academic careers because of the low numbers of women in academia. In their minority situation, women in SET can seldom cooperate directly in their workplace and therefore only a low number of leading women in engineering organisations could potentially promote other women's careers. Women with their low numbers have less internal organizational influence, which would be most important for career advancement. Nevertheless, these formal women's networks function for information exchange and solidarity.

As far as direct cooperation among women is concerned, one interviewee spoke of her appreciation of connecting women with each other as a less complicated option:

> *"I think that sometimes women engineers handle problems more impartially. In the case of technical ones as well, I can handle them more personally and collegially."*

This cooperation among women is not easy in practice because the lower proportion of women in the engineering sector means that most of them are working in isolation from one another. In male domains like SET and on leadership levels women professors cannot rely on a powerful internal women's network (Burt 1998; Scheidegger & Osterloh 2004). Female interviewees did not speak about internal women's networks in academia.

Besides direct cooperation between women, there exists the option to use external women's networks without a specific engineering focus. An external women's network can afford emotional and intellectual support.

Learning, Organizing and Mentoring are necessary for Developing a Gender and Network Awareness

Network awareness as well as gender awareness should be part of training for scientific careers. Reflection on stereotypes in relation to gender and technology should be part of such training along with sensitivity to the experience of discrimination without denial and the ability to perceive exclusion processes from networks. Networking as a precondition for obtaining a professorship in SET is an acquired learnt skill. In the field of natural sciences and engineering junior members are introduced traditionally by (male) seniors (mentors):

> *"I was just a beginning graduate student… then he took me to France for a week with him… Well, you have to get to know the people… He didn't have to go there himself, but he also couldn't have sent me there alone because I would have been a little helpless, but like that, it matched quite well... because with networks one has to start at some time, they typically don't fall as a net over oneself."* (Male professor in a technical University)

This male professor shows a firmly networking awareness. Another male interviewee describes how he teaches his students informal networking:

> *"The most important thing that I try to teach my doctoral students is this: Be there until the end of the evening, and stay in the right hotel, in the right bar – all of this will help. And the number of male colleagues is disproportionally higher than the number of female ones…"* (Male professor in a technical University)

This network aware male professor shows also some gender awareness in his observation that women are less engaged in networking, but he does not reflect on the reasons. Men learn network awareness from the beginning of their career quasi as a matter of course from their supervisors while women have explicitly to look for learning conditions. An interviewed female professor presented a contrasting story to the one above; in her recollection, she felt like an outsider within SET, being left alone, yet realizing the importance of networking while not knowing how to do it practically: *"...I had been left very much alone and had to discover how necessary networking was by myself."*

Working in a male domain, one would expect that women as members of a minority group would have needed more mentoring in making a career in academic SET. In fact, they received less mentoring[3] at the beginning of their academic career. Moreover, as Vaske and Schweer (2013) show in their literature review, women, in particular, need strategic protégées. Because they cannot rely on established powerful networks, women need longer mentoring even when they arrive in leadership positions.

Gender and Network Awareness of Equal Opportunity Officers are Prerequisites for Successful Organizational Change to More Equity

In general, gender awareness is not inherent in an organisational culture. It is a result of reflection processes about gender and its interconnectedness with society, institutions and organisations and this awareness affords individual and organisational learning processes.

In organizational culture, gender awareness should indicate the amount of gender equity in:

- organizational influence of equal opportunity and
- coping strategies of female professors between making gender issues explicit and leaving them hidden.

In engineering, traditional masculinity still defines organisational culture (Faulkner 2009) because men in powerful management positions determine work conditions (Höyng & Puchert 1998). Gender awareness in a positive way as to make an organisation more women friendly is not an element of this formal culture and the same is true for informal masculine work culture. Equal opportunity officers who were interviewed, evaluated gender equality in both of the academic organizations investigated.

The central equal opportunity officer interviewed in the technical university[4] talked about two career hindrances for women in science and engineering:

- low gender reflexion in engineering and science cultures and
- co-option practice which results in homo-sociality and not diversity.

Gender equality is very well included in the guidelines of the technical university. Even though the technical university is gender aware, the equal opportunity officer thinks that in fact implementation of equality would not be too successful in changing the organisation; therefore, she believes informal equal opportunity work is more effective. She characterises gender discrimination in assessment procedures in the following ways:

> *"…we as women's affairs officer were criticised we would not look after quality but after gender. In reality, the opposite was true. Men looked after gender and took this as opportunity to state a qualitative difference that means the main difference in qualification has been gender*." (Equal Opportunity offic in a technical university)

This equal opportunity officer is gender as well as network aware and this helps her to analyse biases caused by gender and network differences, and so to react more strategically in discriminating situations.

In the governmental research organisation, only a few institutes have female leaders; the equal opportunity office has been installed under external pressure and against resistance of men working there. The interviewed equal opportunity officer explains that the small number of women is a result of women's lack of double qualification, because for a career as leader of a research institute one needs an industrial and an academic career in university. This reason can be real, at the same time, she does not show reflection of the genderedness of criteria for qualification in a selection process as well as the role of networking there. In her experience women as institute leaders seldom support female junior staff and show distance to equal opportunity work.

DISCUSSION AND CONCLUSION

Social capital of networks starts with awareness, and in this respect, interviewed female and male professors in SET are similar in their statements. They are convinced that for successful leadership in a technical field, inclusion in internal and external networks, especially for information, cooperation and projects is necessary. Both know about network functions, but the starting situation for women and men is different. Whereas men talk about continuity and acceptance at the

beginning of their professorship, women talk about the necessity of fighting for acceptance and against gender stereotypes. Having become aware of this situation, they had understood that they had to struggle for success in a way in which they believe their male colleagues did not have to do (Hendrix & Sagebiel 2014: 285).

Women and men in SET professorial leadership positions are network aware. Being gender aware some of the female professors in leadership positions create their own women's network initiatives and mentoring programs; some of them participate in equal opportunity measures and handle their visibility and discrimination strategically. Even though women professors partly develop their own networks, they miss some of the powerful connections and information restricted to informal men's and old boys' networks. Women professors in SET experience structural informal discrimination, being defined as not fitting (Van den Brink 2010; Zimmermann 2000) and not trusted (Deters 1995; Vaske & Schweer 2013) to be integrated in men's informal mentoring and networks' systems. Gender awareness among women in SET helps them to recognize, and cope with, gender stereotypes; gender aware women can realise and handle men's power games more strategically. On the other hand, it is unclear how far gender aware women will support other women in their career.

Network awareness helps the career of women in SET. To become visible in the scientific community integration into explicit and implicit networks is necessary. Integration in a scientific school strengthens network connections. Being professors, women in SET need network awareness to get information and cooperation especially for research. The informality of men's cooperation (networking) in SET is the important factor (characteristic) for men's networks' power where women often are excluded or do not feel really included because, defined as the "other" they experience not fitting and belonging. Being aware of their exclusion from informal men's networks, they partly do not want to join them, as they do not feel that they would really belong.

Women need combined gender and network awareness to realize their exclusion from informal men's networks and to appreciate women's own networks. Women are aware of the necessity of mentoring, learning and organizing networking. For successful organizational change to more equity, gender and network awareness of equal opportunity officers are prerequisites too.

Theoretical reflections of the results reveal some interdependencies between definition of excellence, the role of gatekeepers and networks for academic careers as already found by Etzkowitz, Kemelgor and Uzzi (2000). Gatekeepers not only define academic cultures but also the rules of networks and networking. The principle of reviews for evaluation of excellence (of research projects, publications and patents) which should secure objective results indeed seems also to produce gender bias (Sagebiel 2015). Both control systems and processes of reviews are the basis of evaluation of projects, publications and assessment. The results of evaluations define academic careers and here gender and technique stereotypes come into play. Women are then disadvantaged as they do not fit criteria (van den

Brink & Benschop 2012) viewed from the perspective of men's interests, their networks and gatekeepers.

In our reflections on academic leadership and careers from the perspective of gender and network awareness, three important conclusions arise:
First, working as a minority in a male field and looking to their own professional careers, women engineers in leading academic positions are mostly sensitive to gender issues and realise that engineering and management in engineering are perceived as being 'archetypical' men's careers (Evetts 1998: 283). Gendered disadvantages for women in natural sciences and engineering have been summarized as a 'cumulative process of discriminating events' throughout life (EC 2012), a phenomenon which many studies have confirmed (Faulkner 2009; 2005).
Second, the 'continuity' example from a male professor can give a gender lesson about networking. He has been able to rely on pre-existing networks in his scientific field as well as in the research institute; he experienced continuity in his career progression in getting his position, including the evidence of successfully networking in the selection committees. This male professor could start or continue his research without any time lag or hindrances, supported by formal and informal networks. Probably, these male strategies will work efficiently for many publications, projects and patents. In comparison with a female professor in a 'discontinuity' situation, it is obvious that this male professor has a numerical advantage in research and publication. Whereas the 'discontinuity' examples of women professors in our study, show how they have to deal with cumulative processes to reduce barriers to their successful academic leadership.

Third, from a theoretical point of view the split in formal and informal networks[5] is central. For exclusion of women in SET informal male networking is most relevant (Faulkner 2005). Even equality politics probably cannot fight successfully against informal networks, especially when the activities are limited to formal equal opportunity work. Equal opportunity officers could try to further gender awareness and so to reflect gender stereotypes, which often result in women's fewer career opportunities. It is an open question whether informal equality strategies could touch the excluding strategies of informal networking. Learning and mentoring networking could counteract exclusion (Van den Brink & Benschop 2012) and increase the trust of men toward women.

ENDNOTES

[1] Rothstein et al. (2001) summarized the differential support of interpersonal networks for women and men.

[2] The paper is based on the German cooperation project between the University of Wuppertal and the Wuppertal Institute for Climate, Environment and Energy Project, lasted from 2009 to 2012 and was funded by The German Ministry for Education and Research together with European Social Funds. Based on several European projects on gender in engineering organizational cultures (Sagebiel 2007; 2010a) the project "Women to the top" asked if leading women in science, technology and environmental organizations will have an impact on innovation of organizational structures and cultures to less masculine ones.

[3] For more information about mentoring and gender in engineering, see Haghanipour (2013).

[4] In Germany, central equal opportunity offices in universities, institutionalized with duties, rights and election etc. by federal and federal state laws, do not have to follow instructions. Two models exist, one in which equal opportunity officers are elected from the staff of the university and one, by which, after a public advertisement a full-time position is occupied. In addition there exist different organizational structures, resources and duties. For more information, see https://www.gesis.org/fileadmin/cews/www/Projektergebnisse/HGiW-CEWS.pdf.]

[5] For academic careers, Maurer (2016: 13) has emphasized the more important informal networks.

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