International Journal of
Gender, Science and Technology

Selected papers presented at the first Network Gender & STEM Conference, 5-6 September 2012, Haarlem, The Netherlands: www.genderandSTEM.com

In association with

NETWORK GENDER & STEM
educational and occupational pathways and participation

Gender and STEM in Germany: Policies Enhancing Women's Participation in Academia

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ABSTRACT

During the past ten years, a number of national programmes have been established targeting an increase in women's participation in the academic fields of science, technology, engineering and mathematics (STEM) in Germany. Women's participation rates *did* increase but still remain low. In the scope of two analyses, we study this development and the relevance of the introduced initiatives for women's representation and career progression. We first provide an overview of the key initiatives, grouped into those (1) "attracting" and (2) "retaining" women in academia. Next, we study the initiatives' specific effects on women's tendencies to enter and stay in academic STEM fields by analysing student survey data and career paths of recently appointed female STEM professors. The survey findings suggest that "attracting" initiatives positively influence female students' decisions to choose STEM fields. Nonetheless, they experience a low level of professional integration. Correspondingly, the career analysis confirms a comparably low share of women "retained" in STEM fields. Yet interestingly, in retrospect, women's relative share decreases by "only" six percentage points from first-year student to professor status; the largest drop occurs at habilitation. We conclude with a brief discussion of the results and their implications for policy makers and researchers.

KEYWORDS

Germany; gender equality; academia; STEM; policies; student survey; retrospective analysis

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INTRODUCTION

Improving the gender balance in STEM fields (science, technology, engineering, and mathematics) is an important issue in many developed countries. In Germany, efforts included the implementation of many new initiatives between 2005 and 2008. The key actors' main motivation for attracting and keeping women in STEM related disciplines was twofold: (1) increasing the overall number of young academics in times of skill shortages, and (2) achieving excellence in research and development by creating a larger variety of research perspectives (DFG, 2008; Schraudner, 2010). This article reveals that the possible effects of the initiatives have started to increase women's presence in STEM, allowing more general implications to be deduced.

Since the first initiatives were introduced, two opposing phenomena could be observed: first, the participation of women in STEM fields increased considerably. From 2005 to 2010, for instance, the absolute number of women graduating in STEM in Germany rose by one third to 30,900 (Anger et al., 2012) and women's share among appointed STEM professors in German universities more than doubled to 271 (BLK, 2006; GWK, 2011a; a relative increase of 4.1%). However, many women still decide against STEM related careers. A male-dominated STEM culture (Solga & Pfahl, 2009) and subject-specific barriers have been identified as the main factors driving high drop-out rates (Derboven & Winker, 2010; Hetze, 2011; Ihsen et al., 2009) and preventing women from reaching top academic positions (GWK, 2012). To study the possible influence of the new initiatives on women's presence in STEM in Germany, this article addresses two research gaps: (1) a *general analysis* of female students' own perspectives on and perception of STEM culture, and (2) a *retrospective analysis* of female professors' current career path evolution.

First, key initiatives are summarized and clustered into "attracting" and "retaining" initiatives. Building on that, the first analysis focusses on "attracting" initiatives: a survey, conducted at the nine largest German Institutes of Technology (TU9), elucidates female students' experiences within the first semesters of their course and helps to answer the question of whether the implemented measures successfully attracted more young women to STEM, as intended. In order to assess the effectiveness of the existing "retaining" initiatives for women's presence, evidence from a retrospective analysis of academic career paths is presented. On the basis of statistical data, primarily provided by the German Federal Statistical Office, the academic careers of a STEM cohort from student to professor status are tracked and new findings on the stages at which women leave academic careers are presented.

Based on these findings, we discuss the presented initiatives' impact on the situation of women in STEM and formulate policy recommendations to advance the on-going discussion.

Initiatives to Foster Women in Academic STEM fields

Within the last ten years, various programmes, policies and measures fostering equal opportunities and excellence in science have been implemented by key German institutions.

Table 1
Initiatives fostering women's presence in academic STEM fields

1. Initiatives to "attract" young women to STEM (academia)
▪ The nationwide **Girls'Day**, initiated 2001, aims at familiarizing teenagers with (mostly technical) work fields, in which women are underrepresented. In 2013, about 110,000 girls attended activities offered by 9,240 organisations from science and business. ▪ **The National Pact for Women in STEM Careers**, launched 2008, has 144 partners from politics, academia, and industry. They set out to increase the proportion of female first-year STEM students up to the European level, recruit women for STEM careers in proportion to the graduation rates and increase women's share in executive positions at science organisations by annually 1%.
2. Initiatives to "retain" women in (STEM) academia
2.1 At universities
Initiatives commenced and financed by the state ▪ **Programme for Women Professors** (2007-2017): to date, 260 new professorships for women have been created. Conditional on the positive appraisal of their equality policies, universities and advanced art and technical colleges can apply for funding for up to three tenure-track full professorships for women, and extra top-up funds. *Scope 2007-2014: 300 million euros.* ▪ **Performance-related allocation of funds** (on-going institutional contracts): German institutes of higher education primarily depend on public funding, which is partially granted based on performance in the fields of research, teaching *and* gender equality. Gender equality related funding is provided if the following conditions are met: installed equal opportunity representatives, binding target plans on measures and on the quantitative representation of women at all qualification levels. *Scope: about 5% of an institution's funding.* **Initiatives commenced by academia – the German Research Foundation (DFG)** ▪ The DFG's **Research-Oriented Standards on Gender Equality**, published 2008, aim at achieving and maintaining gender equality at all qualification levels. DFG member institutions (universities) agreed on enhancing (1) female participation in science and improving (2) structural and (3) personnel policies. ▪ A **good-practices-toolkit**, launched 2007, and **obligatory reports** (2011, 2013) on the implementation of the DFG standards in the 60 member institutions ensure transparency and public accountability. ▪ Annually, the DFG provides around 2.3 billion euros of **research funding** to universities (DFG, 2013). One criterion to obtain funding is the successful implementation of the DFG standards; which was also crucial in the scope of *The Excellence Initiative* programme *(scope 2006-2012: 1.9 billion euros)*.
2.2 At research organisations
▪ The **Joint Initiative for Research and Innovation** (2005-2015) was primarily designed to give financial planning security to the four largest German research institutions(Fraunhofer Society, Max Planck Society, Helmholtz Association, Leibniz Association), which have about 96,000 employees as of 2013. An integral part of the initiative is the agreement on enhancing the participation of women, particularly in leading positions. *Scope 2011-2015: an increased funding by 5% annually, approximately 1.25 billion euros.*

These include the Federal Ministry of Education and Research, scientific umbrella organisations (such as the German Research Association and the Joint Science Conference), institutions of higher education as well as non-university research organisations.

Table 1 provides an overview of the initiatives undertaken. Due to our general research approach, only large-scale programmes that shape the overall STEM environment are described: non-financial initiatives are presented when involving a minimum of 100 partner organisations (Table 1, first section); the criteria for including funding programmes are a funding scope of more than 100 million euros or a minimum of 5% of a science organisation's basic funding (Table 1, second section). A large share of the displayed publicly funded general initiatives (Table 1, 2.1) has been used to diminish the pronounced underrepresentation of female academics in STEM fields (GWK, 2008; Zimmermann, 2012).

Beyond the programmes mentioned, the TU9 undertake large efforts: in 2009, they ran about 132 measures directed at different target groups from children to junior researchers (Ihsen, 2010b). Since then, the number of measures directed at women has further increased (GWK, 2011b). Moreover, a rich set of smaller initiatives such as gender equality labels, audits and rankings – omitted due to lack of space – make science organisations' efforts for gender equality visible for the general public.

Preliminary evaluations indicate that measures targeted at "attracting" (young) women failed to reach the intended goals (GWK, 2011b). Yet, for universities and research organisations, the pressure has continuously increased: the "retaining" measures included in the table incentivise gender equality through funding. As most initiatives have been running for at least five years, effects should be observable. However, comprehensive evaluations are missing to date.

Viewpoints on the Current Situation

This section presents two representative analyses of women's transition and decision points in STEM careers. One of the two analyses is large-scale, the other longitudinal. The first, a student survey, sheds light on the perspectives of female STEM students who participated in "attracting" measures (Tables 1, section 1 and TU9 measures). The retrospective analysis of career paths focuses on the quantitative effects of "retaining" measures on women's careers in STEM fields (Table 1, section 2).

Results of the Student Survey: Spurensuche! – Seeking Traces!

Between 2007 and 2009, the Department of Gender Studies in Science and Engineering at Technische Universität München conducted the research project *Spurensuche!,* a cooperative project of TU9. The main objective was to determine how to increase the number of women in STEM. Taking a gender perspective, the project specifically analysed, inter alia, the effects of measures to attract female students to STEM, and identified decision factors involved in career choices and contributing to dropout decisions.

Theory

In the past, female students and professionals in STEM fields remained a minority group facing male-gendered "cultural" factors – i.e., established rules and norms that define "real membership" of STEM culture – and field-specific barriers (Ihsen et al., 2009; Solga & Pfahl, 2009). Also, common social rules are usually unchallenged, not reflected upon, and persist in (non-) verbal communication processes and attitudes (Ihsen, 2010a). Heine et al. (2006) show that gender remains a crucial factor in study choice for engineering and natural sciences in Germany.

Methodology
With the aim to further identify barriers and opportunities from a student perspective and in a large scale study, a survey was conducted targeting students in the introductory study phase at 18 TU9 STEM faculties (two at each TU9). The survey questions utilized a 6-point Likert scale and were pre-tested extensively. Based on the logic of explanatory sociology (Diekmann, 2002), additional statistical information was captured at systematically selected TU9 faculties. A documentary analysis followed to ensure that individual-level survey data allows conclusions regarding macro-level development to be derived (Coleman, 1990; Diekmann, 2002).

Sample
The surveyed sample consisted of students from the fields of physics, mechanical engineering, electrical engineering, and informatics in their first three subject-related semesters at selected faculties. Because of the low proportion of women among students, *Spurensuche!* needed to capture a large sample (*N* = 4,663, 16% female students).

Results
The student survey suggested a limited impact of measures to attract young women to STEM: female students gather initial and important subject-specific information more frequently from books and the internet (54.0%), followed by teachers and family, and – ranked fourth – via informational or motivational "attracting" initiatives (33.1%; see Figure 1). Compared to young men, they significantly less frequently make subject-specific contacts in their leisure time (27.2% versus 50.6%) and through internships (27.4% versus 36.2%, figures not displayed).

Yet, a significantly larger share of female than male students participated in at least one "attracting" measure (63.4% versus 54.5%; see Figure 1). Most students felt that attendance helped confirm their study decision and their professional interest (no significant differences between genders). Uncertainties were reduced significantly more frequently for female respondents. One out of ten students stated that the initiative even provided him/her with the idea of studying the chosen programme (see Figure 1). In light of the higher participation rate of female students in "attracting" measures, overall, measures were more frequently decisive for the study decisions of female students than of males. Hence, they may have supported the increased presence of women in STEM fields. However, the impact is more limited than speculated in previous studies (Kompetenzzentrum, 2012a, 2012b).

As a second major result, the survey showed that female students are well integrated in a social dimension, but poorly in professional terms. A majority reported good social integration, assessed by two items, "having friends within the course of study" (66.0%) and "feeling comfortable in a predominantly male environment" (64.0%). Professional integration, assessed by two items, was less successful: 14.0% of female students reported that they "continually have to prove own abilities", and 11.0% stated that they were "labelled with 'special status'". A better integration is needed to keep more women in STEM (Solga & Pfahl, 2009).

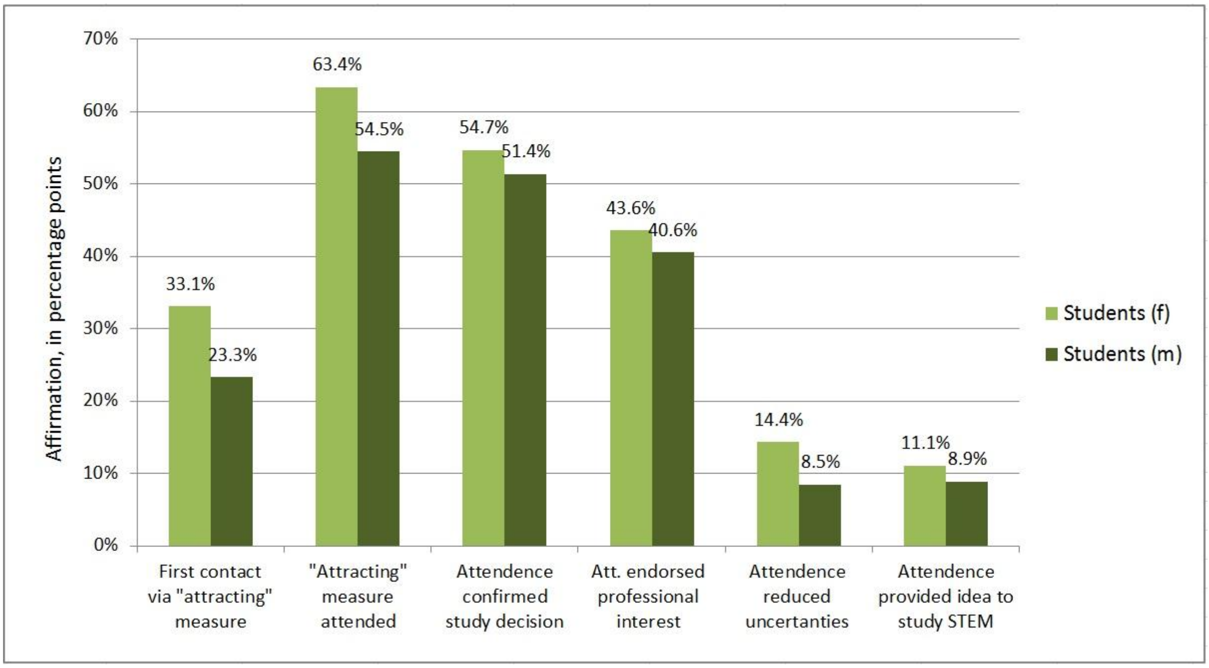

Figure 1. *Students' perspectives on informational and motivational "attracting" measures.*

Results of the Retrospective Analysis: Women Do STEM!

Fraunhofer and the Berlin Institute of Technology jointly performed a retrospective career analysis in 2013. The analysis, inter alia, investigated the quantitative impact of "retaining" measures by revealing the transition points at which women opt out of academia.

Theory

Implicit or subconscious gender-stereotypical beliefs and associations influence aspirations and careers in STEM (Booy et al., 2011). However, 'one-shot' examinations of women in STEM do not provide enough information to capture their development over time and at different transition points of their academic careers (Lind, 2007; Watt, 2010). With the goal of identifying *current* transition points that lead to the status quo, a retrospective analysis of academic careers in STEM was conducted.

Methodology

To track research-oriented careers of several STEM cohorts over time, the methodology developed by Lind and Löther (2007) was adopted, which is based on nationwide, aggregated data.

In Germany, a continuous qualification path from first-year student to a professorship takes 17 years on average (authors' calculations). A STEM professor called in 2010 (appointed a year later[1]) would typically have entered university in 1992-1994, completed his/her diploma studies five years later and earned a PhD in 2001-2003 (see Figure 2). After a post-doctoral position, he/she would have become a "habilitation candidate" (status between post-doctorate and professorship) or worked in industry to then become a professor.

Sample
The main data on students and personnel in STEM fields were provided by the German Federal Statistical Office (2012). Professorship data were extracted from reports by the Joint Science Conference (BLK, 2005-2007; GWK, 2008-2012) and refers to all types of universities.

All disciplines in the STEM subject-groups (1) mathematics, natural and computer sciences, and (2) engineering sciences were considered. Specifically, only students possibly pursuing a research-oriented career, i.e. students enrolled in university diploma studies, were included (according to Keller, 2000; Lind & Löther, 2007).

Results
Backtracking to the approximated beginning of university studies for professors called in 2009-2011, we find for 1992-1994 that 23.7% of all first-year students enrolled in research-oriented careers in STEM fields were women (Figure 2). Until PhD level, the share of women among the student cohort varied between 20.7% (graduation) and 24.0% (doctorate). Figure 2 displays the proportion of women in all STEM related disciplines and in the two subject groups "mathematics and sciences" and "engineering".

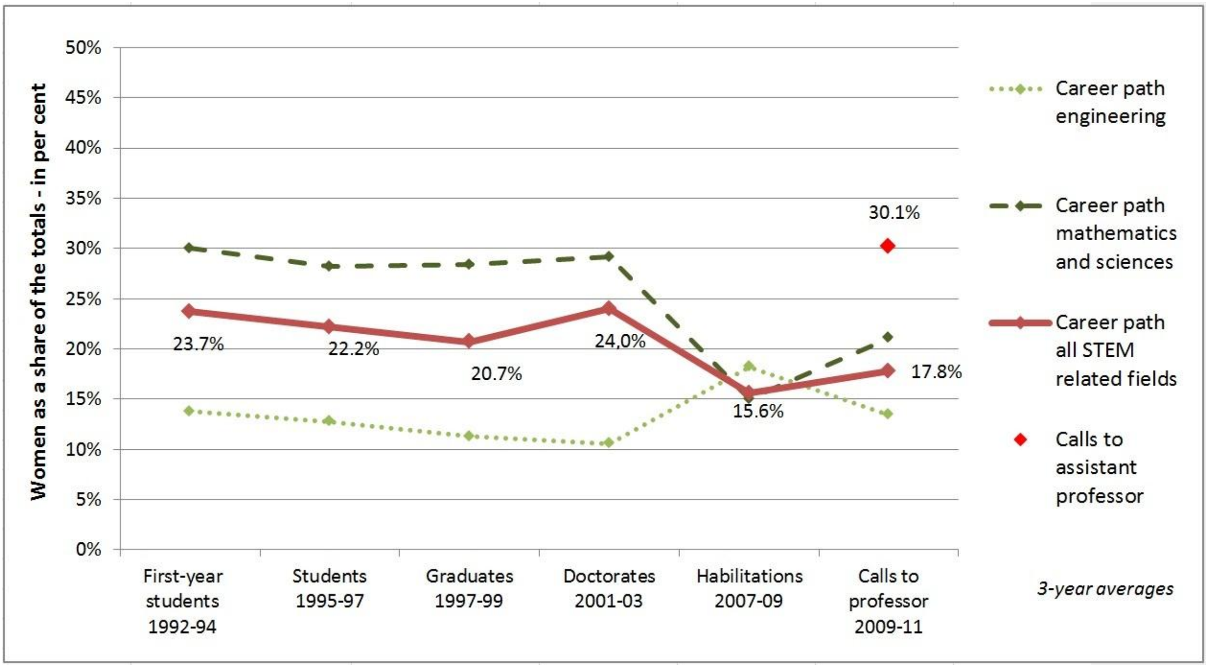

Figure 2. *"Retained" women as a share of research-oriented careers (3-year averages, maximum deviation: ± 1.6%).*

Interestingly, a large difference between the two subject groups before habilitation can be observed: women's share in "mathematics and sciences" is almost twice as high as in "engineering" (around 15.0%). In the German system, habilitation is *the* decisive point for a scientific career (Voß, 2011) and we find that many women decide against it: a large drop in women's share occurs at this stage, driven by the cohort in the field of "mathematics and sciences".
Despite the fact that industry experience is widely accepted as a substitute for habilitation[2] at Germany's applied science universities (awarding around 40.0% of professorships), women nevertheless accounted for only a moderate 17.8% of

all 'called' STEM professors in 2009-2011. Remarkably, the share of women assistant professors (30.1%) is very close to women's share of relevant doctorates (30.2%, 2003-2005, figure not provided). Overall, from student to professor, women's relative share decreases by 6.0%.

Compared to the cohort which was called four years before and which started with a similar proportion of women among students, women's rate of obtaining STEM professorships has increased by 3.6% (BLK, 2006-07; GWK, 2009). Formerly, a comparable increase had only been achieved within a timespan of ten years (BLK, 2005-2007). One explanation might be that the "retaining" initiatives undertaken have supported this positive development.

CONCLUSION

The richness of the initiatives implemented in Germany to foster women's representation in STEM fields gives the impression that gender equality has improved throughout the last decade. The analyses presented support this perception only partly – female students still report a non-inclusive STEM culture and women opt out of STEM-related academic fields in larger proportions than do their male fellows.

Important "attracting" and "retaining" initiatives were summarised first. Subsequently, two analyses were presented. The survey conducted at TU9 universities reveals that "attracting" measures positively influenced 55.0% of polled female students' decisions to opt for a STEM subject. Yet most respondents do not feel well integrated professionally in their programmes. The retrospective analysis confirms women's large underrepresentation for recently appointed female professors at every stage of their academic career. A new insight is that among the cohort analysed, women's relative share decreases by 6.0% from student to professor status, while the largest drop occurred in mathematics and sciences at habilitation. The recent 3.6% growth in the share of women among those professors, to a total of 17.8%, may be partly attributable to the "retaining" initiatives, as growth was only half as large during the preceding decade. Considering the number and the scope of the various and largely independent initiatives, the overall effect is rather limited.

Both analyses have certain limitations. First, we focus on academics, although a broader view, including non-academic occupational pathways is needed to more fully capture the situation of women in STEM fields. Second, our analyses do not reveal the effects of the initiatives described *separate* from other exogenous factors. To mitigate this drawback, we applied multiple methods (survey, data analysis, literature review). Large-scale research investigating both the individual rationales of women and STEM employers is needed to more thoroughly address both restrictions.

Given the findings presented, recommendations are needed for the following identified challenges: (1) "attracting" (young) women to STEM subjects and to high academic positions, (2) "retaining" women in these fields, and (3) increasing the effect of respective measures. We recommend fostering a comprehensive qualitative integration of women into STEM culture (Bührer & Schraudner, 2006; Solga & Pfahl, 2009), focusing on four points:

(1) ensure high-school teachers' and parents' support in male-gendered STEM subjects to foster young women's interest (Lazarides & Ittel, 2011) and thereby *increase their entry rates among first-semester students;*
(2) work on "cultural barriers" (Ihsen et al., 2009), especially by reframing subjects' technical image and amending programme curricula (GWK, 2011b) *to retain more women in STEM subjects;*
(3) establish more attractive and flexible research-oriented careers (Wissenschaftsrat, 2013) *to attract talented women to high academic positions*;
(4) initiate concerted action of all involved parties – instead of small, independent measures – *to achieve sustained progress*.

Our findings for Germany are relevant to many other Western countries. Only if key actors truly embrace diverse perspectives and talents in STEM fields and accept holistic, systemic change, will ambitious and highly motivated female talents "who *enjoy* the technical challenges" (Herman, 2009, p. 50; authors' emphasis) get *and* use the chance to participate equally in STEM related careers.

ACKNOWLEDGEMENTS
The authors gratefully acknowledge the helpful comments provided by Martina Schraudner and Andreea Firca.
The primary research project conducted by Gender Studies in Science and Engineering at Technische Universität München, underpinning the results presented in this paper, was funded by the Federal Ministry of Education and Research within the framework of the National Pact for Women in STEM Careers and the European Social Fund.

ENDNOTES
[1] In Germany, professorships are awarded through appointment procedures: after successfully applying for an advertised position, the first-placed candidate is "called", i.e. he/she receives the job offer. Subsequently, the offer's conditions are negotiated. Following a successful process, the candidate is "appointed" professor. We use data on *called* professors, since complete appointment data is not available. This is no major drawback, as it has been documented that the share of women who are called and appointed professors corresponds (GWK, 2010-2012).
[2] Based on several studies (e.g., Krimmer et al., 2003), the authors assume that the time span of habilitations and industry experiences needed for professorships are similar.

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