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A Woman in the Man's Culture of Engineering Education

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Abstract. The study is aimed at identifying barriers to the research career of women in the academic environment of a technical university. The authors present the results of their study of the women's status in the academic community. The study is based on a quantitative (questionnaire survey) and qualitative (biographical interviews) analysis of the opinions of students and teachers of STEM disciplines of a technical university about the features and problems of women's professional careers. It is established that women of the same university evaluate the presence and degree of influence of barriers to the research careers differently. In some cases, women assessing their professional status note that they do not feel professional discrimination on the basis of gender. In general, the analysis revealed that women who received a STEM education use a strategy of avoiding a research career and choosing alternative career options: either outside the academic environment, or by transitioning to teaching as a way to circumvent gender barriers in grant and publication activities.

Keywords: engineering education, academic environment, masculine culture, female teacher, women's professional career, professional status, gender barriers

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Introduction

Gender evaluation of the academic environment implies a multi-aspect analysis: it covers problems of feminization of education (including higher professional education), gender inequality in the university management ("female staff – male management"), manifested and hidden stereotypes, gender segregation by training areas (existence of "female" and "male" departments), gender risks and other topics. These effects are manifested most clearly in "male sanctuaries" – technical departments of the university.

In the past few years, gender segregation in engineering has become the subject of active interest of economists, sociologists and politicians [1–2]. Researchers note that the persistence of structural barriers to advancement in engineering and in the academic space, as well as the preservation of the "gender gap in STEM education and STEM employment", are some of the reasons for the low representation of women in the engineering profession [2, p. 5].

General gender problems of women's employment in the labour market, which were thoroughly studied by the authors, influence the strategies of women's behavior in the academic market [3; 4]. These problems include: difficulty of finding a balance between work and family, work and children; professional segregation of employment areas; underestimation of

abilities and capabilities of women; discrimination in wages, career advancement, process of hiring; sexual harassment.

At the same time, the position of women in the professional field of a technical university, in the "male" field of engineering, is complicated by the influence of a number of additional factors. Low representation of women in the teaching of STEM disciplines means there are no support groups, there is a prevailing "cold climate" (weak formal and informal connections) and lack of mentors. This "male field" still possesses stronger stereotypes about the inability of women to work in engineering. Women's knowledge and abilities are underestimated; their career (administrative) growth opportunities are limited [5; 6]. Attempts to integrate more women into engineering are only partially successful, since gender inequality is rooted in cultural associations between engineering, technology and masculinity [7]. Gender imbalance in technical specialties is already observed at the stage of enrolling in the university [8]. Gender stereotypes, parental expectations, and lower general confidence of girls in their knowledge have a certain influence. As a result of the aforementioned factors, the share of women who want to study technical specialties decreases by the time they enter the university. Even in cases where women choose to study engineering, the likelihood of them working in this field is lower than for men, although there are no gender differences between their academic performances. To characterize this phenomenon, American and European researchers use the "leaky pipeline" metaphor [9].

Two issues are most often discussed in studies of the position of women in the engineering field: how to attract talented girls and how to keep them in engineering. The purpose of our work was to study the gender gap, the combination of "gender-friendly" policies for students in higher education and an unfriendly university environment towards female STEM teachers, as well as to identify behavior strategies of women in the dominant masculine culture of a technical university.

Methods

The resource approach used in the sociology of youth is the methodological basis of the study. In order to conduct a comparative analysis of the professional potential of future engineers, which is understood as the scope of various personal capabilities in several aspects, the authors evaluated motivation of the already implemented choice of educational institution and revealed plans for the near professional future. Along with this, the authors conducted a comparative assessment of the professional potential of girls studying at different levels of STEM programs: bachelors, masters, postgraduate students. The "vertical" aspect of the analysis revealed an increase in the level of "gender persistence" – the girls' confidence in their choice of engineering profession.

To identify gender features of the professional socialization process of engineering students, the research team conducted a series of field studies in 2014–2018: the survey of university applicants (N = 200) who had chosen engineering education programs (mechanical engineering, radio electronics, information, physical or chemical technologies) [10], the survey of bachelor students (N = 200) and master students (N = 198) of STEM immediately after their admission (enrollment) in full-time bachelor and master programs [11]. To clarify the findings, the authors used the data of the seventh stage (2016) of sociological monitoring of students of the Ural region. Over the course of 20 years, the monitoring has explored a range of critical issues for students, including problems of choosing profession and searching for professional path [12].

The analysis of women's behavior strategies in the scientific and pedagogical engineering environment was carried out using the case study method. This research strategy was aimed at consistent and detailed study of a single object using various available methods of collecting information. The largest university of the Ural region, the Ural Federal University, was chosen as an object of study. UrFU was created as a result of the 2011 merge of the Ural State University

Table 1

Motives for the students' choice of engineering specialties: gender aspect (%)

Motives for choosing a profession	Bachelors		Masters		Postgraduates	
	Women	Men	Women	Men	Women	Men
Interest in the profession	39	30	54	56	51	55
Attracted by prestige and authority of the university	40	34	54	46	64	47
Attracted by the prospect of finding a good job after university	33	37	39	36	30	31
Desire to get a diploma (no matter where and what kind)	27	34	50	51	46	55
Attracted by an active student life, "along with friends"	20	18	25	34	22	17
Considered their abilities to be the best for this field	16	10	14	21	27	25
Influenced by family tradition, parents	10	10	57	37	38	36
Influenced by studying in a specialized class, college, lyceum	11	7	39	23	43	34

* The amount exceeds 100%, since one respondent could give several answers.

(USU) and the Ural State Technical University (USTU-UPI). A questionnaire survey of university teachers was conducted to assess the potential of female teachers (N = 290, 2017). The authors used quota sampling. Gender, age, and education were used as quotas. Women and men were equally represented. One fourth (26%) of female respondents teaches engineering disciplines, one fifth (20%) teaches natural science disciplines. Additionally, the authors conducted a biographical interview with female teachers of STEM disciplines to study the barriers that women face in their academic careers (N=20, 2018). The analysis of incidents that women face in their daily professional activities revealed the existing barriers in the scientific career of female STEM teachers.

Research results

Comparative assessment of the professional potential of female and male students of engineering educational programs revealed several common features. Motives for choosing an educational institution, rather than a profession, prevail in the structure of preferences of both women and men. The students' abilities are often not considered when choosing an educational program. Interviews with the prospective students who applied for technical programs revealed an interesting fact: the majority of respondents (49% of men and 58% of women) assess their professional choice as situational; they are willing to change it without regret. Students do not choose the engineering profession; they choose labor-intensive, high-quality, basic education acquired in a technical university, which will allow them to undergo accelerated vocational retraining in the future.

The authors conducted an analysis of gender patterns in the choice of an engineering profession by high school girls (physics and mathematics classes), by applicants who have already submitted documents for engineering programs, and by students already studying at three levels of higher education (bachelor, master, postgraduate programs) at technical departments of the university. The analysis revealed the dynamics of changes in gender attitudes. It also allowed the authors to compare women's opinions and assessments of the engineering profession at the "entrance" to the professional field, at the projective entry into the labour market, and during the planning of the professional future after completing the educational program.

The analysis of the authors' research materials identified several «impact points» in the choice of profession among women in STEM programs: parental influence («family or engineering capital»), having abilities in this field, a form of the pre-university training (studying in a specialized class, college, lyceum) and, as a result, growing personal confidence in the ability to master labor-intensive "male" training programs (*Table 1*).

The analysis of the survey of high school students and university applicants revealed that the girls' choice of "male" profession begins at the stage of choosing a specialized class at school. Studying in such specialized classes increases their confidence in the ability to master the labor-intensive engineering training program and forms "gender resilience" in engineering [13]. Successful training in educational STEM programs adjusts professional plans of female engineering bachelor students. Their confidence in their abilities and capabilities to master labor-intensive engineering educational programs increases. The share of men is twice the share of women among the bachelor STEM students at the university; this ratio changes somewhat in favor of women among master students. There is only a third more men than women among STEM master students [14]. Women evaluated studying at engineering master and postgraduate programs as an additional chance of employment, an opportunity to realize their abilities in practical engineering work. The conclusion is that, while professional gender stereotypes remain, an active process of their transformation is underway. Successful mastering of educational STEM programs adjusts the motivation and professional plans of female graduates of engineering bachelor programs.

Comparative assessment of actualization of the students' abilities did not reveal significant gender differences in the perception of professional values, as well as in the degree of gender identity manifestation in male and female engineering bachelor students. Utilitarian attitude to the future profession, the desire to build a career and to realize their potential in the future work prevails in the list of professional values of both male and female engineering bachelor students.

Significant gender differences reappear in the assessments of students' professional plans. The lack of seniority and practical work experience in the profession worries female students a lot more than male students, even though they all have equally insufficient practical experience. Low wages are a concern for all respondents, but these concerns are more pronounced among women. Two types of resources for social success, among those provided, prevail in both men's and women's answers: fully formed personal qualities (intelligence, abilities, business acumen, resourcefulness) and social connections, acquaintances. In the latter case, it is not so much about family and kinship support, but rather about gaining contacts and connections in the professional and business environment. Women estimate the significance of such resources slightly higher than men [12].

The impact of social and cultural stereotyping mechanisms that allow and encourage the attribution of self-realization abilities to a person on the basis of sex is weakened in the social field of education. Gender differences are insignificant in the assessments of the potential realized in the educational field. The influence of stereotypes is most pronounced at the «entrance» into the educational field and at the «exit» from this field, in assessing prospects and problems of future employment, professional plans and expectations. According to experts, education is the only field that has clear «rules of the game» [15]. The rigid selection system in education does not depend on either gender or age, but on the level of knowledge.

The situation is different in the academic employment field. There is a persistent gender bias in the demographic structure of university specialists. The bias is very significant in technical departments of the studied university: the mechanical-engineering department has 26% of female teachers, radio engineering and energy departments have approximately 20% of women in their faculty, and only a quarter (25%) of women work at physical and technological departments.

An academic degree and an academic title of a university teacher can be assessed as a significant resource characteristic, which reflects the ability of its owner to solve research tasks of a certain level of complexity. The presence of an academic degree reduces the risk of losing a job in current conditions of a general deterioration in the professional labor market for teachers.

Table 2

Professional qualifications and vocational characteristics of teachers of a regional university: gender aspect (%)

Age	Academic degree				Academic title			
	Candidates of Science		Doctors of Sciences		Associate Professors		Professors	
	Women	Men	Women	Men	Women	Men	Women	Men
25–35	14	19	2	3	2,5	3	0	0
35–45	30	18	22	7	24	12	9	2
45–55	21	14	24	10	24	17	15	7
Over 55	35	49	52	80	49,5	68	76	91
Total:	100	100	100	100	100	100	100	100

The analysis of the official university statistics led to a conclusion that female teachers use opportunities to increase their competitiveness and strengthen their status positions more actively than men. The share of women of active age with a degree and a title is 1.5–2 times higher than the share of men (Table 2).

The increase in the share of women with degrees in the age group "over 35" can be assessed not only as an effect of accumulated advantage, but also as accumulated lag, a loss of starting opportunities. The analysis of Russian statistics on the average age of postgraduate students revealed a demarcation line of 26–27 years, after which the number of women among postgraduate students begins to exceed the number of men. There are more men in the age group «under 26».[1] Women start to prevail in the age group «over 35» among master students of engineering programs of the studied university. Women receive degrees and titles after solving family problems and having children, often after unsuccessful attempts to find a job in engineering.

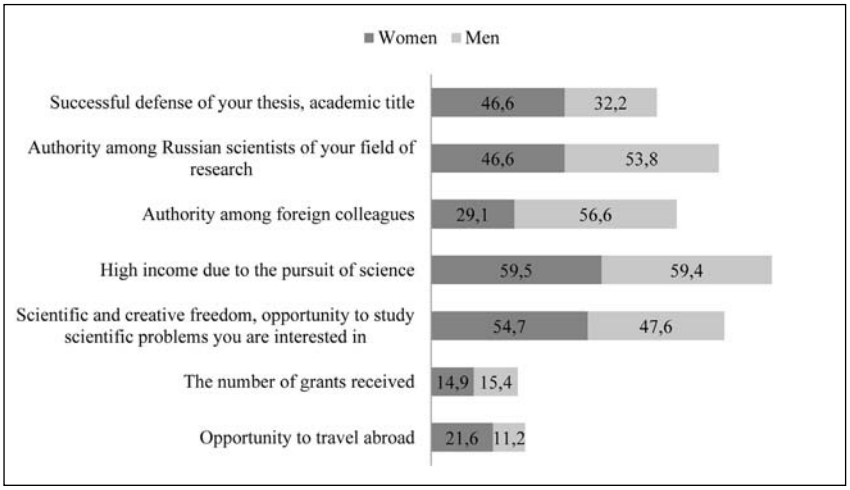
Female, 27 y.o., engineer in expertise, civil engineering: «*I couldn't find a job in my profession, no matter how much I tried. Turning to science was a way to stay in the profession, in a sense. And to develop as an architect, albeit in a theoretical sense*».

The respondents have common understanding of the criteria for the success of a scientific career: academic freedom, decent salary. However, there are certain differences: male university lecturers value recognition among the professional community, foreign and Russian researchers. Female teachers find safety and formalization of their status more significant: successful defense of their thesis, academic title (*Fig. 1*).

Women who specialize in natural sciences and engineering still face obstacles at every step of their careers, despite having made some progress. Western sociology called the discrimination of women in the field of science and technology the «Matilda effect» – in honor of Matilda Joslyn Gage, the first activist who spoke of the discrimination of women in science.[2] Canadian scientists confirmed this effect by the fact that male scientists are quoted more often than women. In 2008–2013, they analyzed engineering articles and authors of these publications on the Web of Science platform [16]. A comprehensive gender analysis revealed an underestimation of the role of female scientists and an overwhelming (80%) dominance of male publications in engineering. A large share of scien-

[1] Berezina, E.V., Lebedev, K.V., Pluzhnova ,N.A., Prokhorova, L.V., Fedin, A.V. (2017). *Statistika nauki i obrazovaniya. Vypusk 3. Podgotovka nauchnykh kadrov vysshey kvalifikatsii v Rossii* [Statistics of science and education. Issue 3. Training of highly qualified scientific personnel in Russia: information and statistical material]. Moscow: Scientific Research Institute – Federal Research Centre for Projects Evaluation and Consulting Services, 170 p. Available at: http://csrs.ru/archive/stat_2017_staff/staff_2017.pdf (In Russ.)

[2] Women's Rights Room. Available at: http://www.matildajoslyngage.org



* The amount exceeds 100%, since one respondent could give several answers.

Fig. 1. The university teachers' understanding of the criteria for the success of a scientific career: gender aspect (UrFU, 2017), (%)

tific collaborations comes from cooperation between men, while women form their joint work in less than 7% of the total number of cooperation between engineers [16]. Despite the fact that female engineers publish their articles in journals with a higher impact factor than their male counterparts, their work receives lower recognition and fewer mentions in the scientific community [16].

In 2017, Russia adopted the «National Action Strategy for Women for 2017–2022». One of the provisions of this strategy includes «*creation of special forms of grant support and organization of professional competitions for female innovators in order to stimulate the participation of women in high-tech industries and innovation activities*».[3] This provision is a focal point of women's participation promotion in STEM. It is implemented in the framework of the working group «STEM Committee» which was created on the platform of the Eurasian Women's Forum. The forum is designed to facilitate the development of talented women and their promotion to leadership positions in high-tech industries.

In many cases, grant applications from women are evaluated more rigorously than similar applications from men.

Female, 31 y.o., Candidate of technical sciences, Associate Professor: «*I haven't been able to receive a single grant from the RSF for 2,5 years, even in the competition of young scientists under 33 years old. The reasons are clear to me, it's because I am a woman. I have been reviewing applications for two years; I haven't had a single application from a woman. Inside the applications, there are one or two women, and this is primarily mathematics, physics, energy. There wasn't a single female supervisor, and I reviewed about 40 projects. They have me as an expert, but they don't give me money, because it's very unusual for a woman to be a leader. There's also age: if I were a 30-year old guy, then yes, there would've been a chance. But if I am a 30-year old woman and I have high publication activity – no! Talking about my projects, the last two reviews of two different projects were positive ("approve, approve"). You just have to be accepted when all three reviews are positive, but the Council didn't accept both projects*».

[3] On approval of the National Action Strategy for Women for 2017–2022: Order of the Government of the Russian Federation of March 8 2017 N 410-p. Available at: http://www.consultant.ru/document/cons_doc_LAW_213740/ (In Russ.)

The preservation and dominance of stable sexist attitudes among male STEM teachers was clearly manifested in their answers to an open question asking for clarification of their position on the presence of more attractive research areas for men or for women. Half of respondents agree that all areas of scientific research can be equally attractive for both male and female researchers. However, a third of male respondents do not agree with this statement. Typical arguments in their responses are as follows:

«Women, as a rule, are afraid of mathematics. They believe it is difficult, although it's not. So they avoid technical and natural sciences and prefer stamp collecting»;

«Women aren't capable of analytical thinking; women don't have high working ability and concentration».

There is hidden or "benevolent" sexism in assessments of the status of female engineers, as well as distrust not only from men, but from women themselves.

Female, 51 y.o. «*Now, after having worked for so long, I think that technical specialties require a male mindset. It's better to have male leaders in situations where decision-making and a cold / calculating mind are required»*.

Female, 57 y.o. (previously worked in production, a faculty member now*): «The only obstacle for a woman is her emotionality! Although many men have it, too. Even in our university environment, there are a lot of men who are psychologically women (who behave like women). Women are tied to everything negative, so if you behave like this, you are like a woman. Or you behave like a man: you are consistent and responsible for your actions, you make the right decisions, and you are likable. It turns out a lot of my female acquaintances act like men. But everyone can achieve success, everything depends on the situation. Success is not a sign of masculinity»*.

Sometimes women endow men with a set of personal qualities indicating a fairly high level of professionalism: consistency, goal pursuit, logical behavior, cold mind. The influence of stereotypes and a positive perception of a male gender are clearly manifested in the informal female discourse of the engineering profession. The manifestation of masculinity is in a direct positive relationship with the improvement of professional status. As T. Shchepanskaya rightly observes, symbolic gender constructs are in an asymmetrical relation to the construct of professionalism: masculinity tends to be directly related to professionalism, while femininity tends to be inversely related to it [17].

People tend to choose professions that they consider suitable for their personalities. The choice of profession is indeed linked to gender identity. In our opinion, however, the choice of behavior strategy is the main and very complex problem faced by individuals in "gender-atypical" professions. A woman can distance herself from stereotypes and behave as a professional with no regard to gender in the «male» field of employment. Conversely, a woman can comply with persistent gender stereotypes in the choice of profession, as well as with behavioral norms in the chosen field.

Female, 37 y.o. (faculty member): «*Can you imagine? Every time you join the men's team you have to prove to every man that you have the right to be an engineer, and only then you can have other conversations. Because most of them believe that the chicken is not a bird, and the woman is not an engineer. That's it, that's the standard phrase. You prove it so that they talk to you. Guys usually try to resist, but they're not good at it now. Anyway, they have already surrendered everything they can, they are ready, they have already accepted this component*».

Some researchers strongly believe that the engineering profession presupposes the presence of personality traits traditionally assessed as «masculine». Therefore, those who have chosen a gender-atypical occupation usually exhibit gender atypical personality traits. As a result, the process of personal deformation of women occurs in the «male» profession [18]. One of the behavior strategies used by women in gender atypical professions can be defined as female identification with a male style of behavior, such as «I have always gotten along bet-

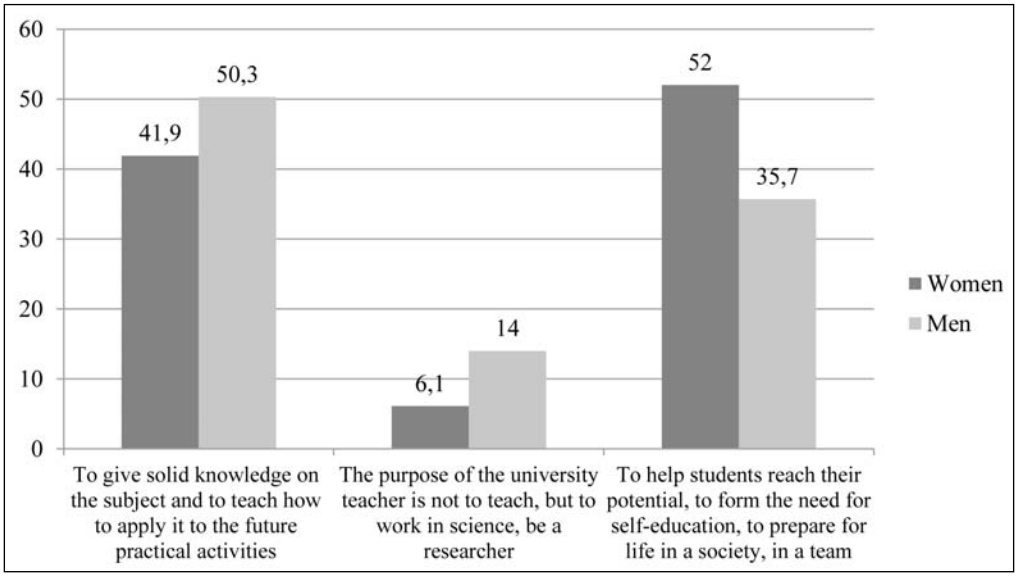


Fig. 2. Teachers on the purpose of their professional activity

ter with boys» [19] or «Hide femininity, dress in masculinity» [20].

Female, 57 y.o. (previously worked in production, a faculty member now): «*I believe that a lot of my masculine qualities formed in the engineering and technical environment (I formed them deliberately!). For me, male qualities are: consistency, goal pursuit, logical behavior, and so on. All this came from those men who worked in workshops and other workplaces. They somehow managed to pass their life experience and know-hows to me! Transformation is there, and it's a normal transitional situation*».

Female, 51 y.o.: «*I met such women, but they are exceptions. These are women with masculine traits: leaders, commanders, they are tough, they have masculine appearance*».

Teaching science is a less stressful alternative to working at a research university or laboratory [9]. Some female teachers prefer to limit themselves to reading lectures and conducting practical classes with students. They do not participate in research work.

Female, 31 y.o., Candidate of technical sciences: «*In our department, most of the teachers are women. We now have those who are over 50 years old, and those who are 25–27 years old. We practically don't have any middle-aged ones. All women over 30 years old almost never get published, they don't do science, they just teach. They all, more often than not, have nothing to do with practical work. And they don't want to. They just come once a week, give a lecture and leave*».

The role of a teacher fits perfectly into the stereotypical notions of female professions: educating and caring for younger generations. In attempt to understand the goals of their activity, women position themselves as «teachers-educators», whose purpose, above all, is to help students reach their potential, to prepare for life in society and in a team. Male teachers perceive the goal of their professional activity more pragmatically. They position themselves as «mentors», whose purpose is to teach practical application of acquired knowledge (*Fig. 2*).

One of the most typical barriers in the professional and academic career of a female teacher is the difficulty of combining family / children and working at a university as a teacher. Respondents note the difficulty of combining an academic career and having children without the support of a family and social services.

Conclusion

The study identified a number of barriers that impede the professional development of women in the predominant masculine culture of a technical university. These are common gender problems for working women: family and work balance, children and work balance, professional segregation, underestimation of women's abilities. At the same time, the position of women in the professional field of a technical university, in the "male" field of engineering, is complicated by the influence of a number of additional factors. There are stronger stereotypes about the inability of women to work in engineering, in this "male" field. Women's knowledge and abilities are rated lower; they have limited career opportunities. Attempts to integrate more women into engineering are only partially successful, as gender inequality is rooted in cultural associations between engineering, technology, and masculinity.

Women of the same university evaluate the presence and degree of influence of barriers to development and career differently. The analysis of women's practices and their desire to circumvent these barriers made it possible to identify several typical behavior strategies of female STEM teachers. In some cases, women assessing their professional status do not feel that they experience professional discrimination on the basis of gender. They choose and successfully implement the strategy of professional self-realization; they are satisfied with the recognition of their achievements by colleagues and students. The achieved balance between work and family, work and raising children is often the merit of the woman herself, as well as the help and support of her family (husband, parents).

The analysis of incidents revealed that in most cases women use strategies of avoiding a research career and choosing alternative career options as a way to circumvent gender barriers in grant and publication activities. The analysis of interview data revealed that a male scientist is more likely to receive grants for research than a female researcher. The status of women is often limited to the role of «implementers». At the same time, even those female STEM teachers who are «successful in science» at the university are often not focused on the administrative career and status promotion.

A common feature of all female teachers of engineering disciplines at technical university is a categorical disagreement with the assumption of women's inability to innovate, as well as with a low assessment of their intellectual abilities.

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Женщина в мужской культуре инженерного образования

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Аннотация. *Исследование направлено на выявление барьеров, препятствующих исследовательской карьере женщин в академической среде технического университета. Авторы приводят результаты собственного исследования положения женщин в академической среде. Исследование основано на количественном (анкетный опрос) и качественном (биографические интервью) анализе мнений студентов и преподавателей STEM-дисциплин технического университета об особенностях и проблемах профессиональной карьеры женщин. Установлено, что наличие и степень влияния барьеров, препятствующих исследовательской карьере, неодинаково оцениваются женщинами одного университета. В отдельных случаях женщины, оценивая своё профессиональное состояние, не ощущают дискриминации в профессии в зависимости от пола. В целом, анализ выявил наличие у женщин, получивших естественнонаучное и инженерно-техническое образование, стратегии ухода от исследовательской карьеры в сторону выбора альтернативных вариантов: либо вне академической среды, либо уход в преподавание как способ обойти гендерные барьеры в грантовой и публикационной активности.*

Ключевые слова: *академическая среда, технический университет, инженерное образование, женщина-преподаватель, маскулинная культура, гендерные барьеры, профессиональная карьера женщины*

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