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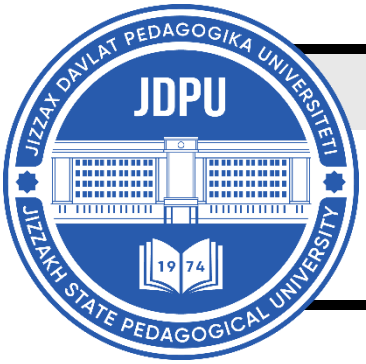

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INTERNATIONAL EXPERIENCE IN SOLVING THE PROBLEM OF GENDER INEQUALITY IN STEM INDUSTRIES

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ABOUT ARTICLE

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Abstract: Being one of the significant problems in modern society, the topic of gender inequality in STEM (science, technology, engineering and mathematics) is extremely relevant. This article examines the international experience of combating gender inequality in STEM industries, practices and examples from different countries that have proven their effectiveness. The author analyzes mentoring and mentoring initiatives, special degree programs for women scientists, as well as legislated measures to ensure equal opportunities. It describes projects, surveys and campaigns aimed at attracting girls and young women to study STEM subjects and supporting them at all stages of their careers. The gender imbalance among students receiving STEM education is an urgent global problem. According to the data of 2024, the proportion of boys in most STEM fields around the world still significantly exceeds the proportion of girls. The article examines practical foreign experience in solving the problem of attracting an increasing number of girls and women to the STEM field.

Introduction. Statement of the problem.

The gender gap in STEM industries is a global problem that requires coordinated efforts by governments, educational institutions and society to solve it. In the modern conditions of

intensive development of science, technology, engineering, computer industry and information resources, the vast majority of jobs require STEM skills in various forms.

Around the world, in both developed and developing countries, there is a persistent gender gap in science, low representation of women scientists in the fields of technical and natural sciences, their absence in senior management positions. According to UNESCO (2024), globally, women still make up only a third of all researchers (33 percent) [17]. In the largest American technology companies, the so-called Big Tech group (Google, Amazon, Facebook, Apple, Microsoft), women make up from 29% in Microsoft to 45% in Amazon of the total workforce. Women occupy 26.5% of executive, senior and managerial positions in S&P 500 companies [5]. In this regard, the gender gap in STEM education and STEM employment has recently become a major concern for scientists, with young women and girls being significantly underrepresented among students in technological universities and faculties and, as a result, in the most technological and highly paid sectors of the economy. This applies even to highly developed countries. For example, despite the highest ranking in STEM, being in the top 5 countries for natural science research and technological experience, studies conducted by scientists in Japan and Germany, separately in each country, showed that women are underrepresented in physics, engineering and computer science, and are subject to negative stereotypes in STEM in both countries. In STEM fields, less than a third of undergraduate students were women (Germany: physics: 30%, engineering: 24%, computer science: 21%; Japan: natural sciences: 27%, engineering: 14%) [12].

Among the reasons for the existence of such a gender gap in STEM specialties, first of all, it is necessary to note socio-cultural factors, prejudices, gender stereotypes associated with professions, widespread ideas about male scientists and engineers than about women in similar positions [19]. In the field of technology, there are few female personnel, who are eliminated at the stage of choosing a profession, due to which there is a widespread lack of female role models. A 2019 study by Harvard scientists showed that the gender gap in STEM begins in school. By middle school in the United States, among children dreaming of becoming mathematicians and engineers, there are twice as many boys as girls. The same trend can be seen in high school: girls make up 61% of biology students, 52% of statistics students, and 50% of chemistry students, but only 23% of computer science students and 29% of physics students. In college, the gap widens: men are five times more likely to study engineering and IT [13]. Research into the causes of the gender gap shows that only 11.2% of programmers are women. The main problem is that women and girls often do not even consider a career in the IT industry.

A global study by the Organisation for Economic Co-operation and Development (OECD) found that only 1% of 15-year-old girls want to work as ICT specialists, compared to 5.5% of boys [8].

Presentation of the main research material.

One of the first to raise the issue of girls' declining self-esteem in mastering the exact sciences, and especially mathematics, was the report of the American Association of University Women, "How Schools Undervalue Girls" (1991). The study involved students in the fifth, eighth, and eleventh grades. This decline was identified throughout their secondary school years, which subsequently deprived girls of the motivation to enter technical universities. In contrast, boys' self-esteem did not decline. A similar study (in a metropolis and a provincial city in Russia, 2018) among 5th, 8th, and 11th-grade schoolchildren in Moscow and Gubkin (Belgorod Region) showed that only 35% of girls preferred technical and natural sciences, while for boys this figure was almost twice as high (65%). 64.9% of girls from the 5th grade do not consider the STEM field a priority for themselves, only 10% of girls in the 11th grade indicated high competence in mathematics, while for boys this figure reaches 38%. The opposite dynamics of self-esteem of boys and girls is also noteworthy: for girls it falls with each subsequent grade - from 17% in the 5th grade to 10% in the 11th, while for boys, on the contrary, it grows - from 20% in the 5th grade to 38% in the 11th. According to the researchers, one of the reasons negatively affecting the choice of STEM disciplines by girls for study is their low assessment of their abilities in these disciplines. Thus, it turned out that if girls assess their knowledge low, then in 73% of cases they do not choose STEM disciplines [3].

Scientists from the Russian Academy of Education (RAO) analyzed intellectual abilities, academic achievements, and what schoolchildren want to become (2021) to identify the factors that prevent schoolchildren from mastering STEM professions. The study involved 1,638 students in grades 7–11 from eight Russian regions. Experts found that girls are almost twice as likely as boys to choose STEM professions (32% versus 63%). It turned out that gender stereotypes play a decisive role here, which, regardless of individual psychological characteristics, contribute to a decrease in girls' interest in natural science and technical fields of study [15]. Since the 1970s, scientists have been conducting research on the problem of differences in the acquisition of mathematics by boys and girls, the role of teachers in shaping schoolchildren's orientation toward STEM disciplines. Often, the low level of gender culture of teachers, their insufficient use of a gender approach in the orientation and choice of STEM disciplines by schoolgirls create a not very favorable environment for the self-disclosure of their abilities in STEM disciplines. A study of gender ideas and ideals of teachers (2017) showed that in the education of modern boys and girls, teachers are still guided by gender stereotypes

of traditional culture, creating invisible but quite effective barriers to the development of girls' interest in STEM education and STEM professions, orienting them mainly towards professions in the social and humanitarian, artistic profile, and auxiliary and service spheres of labor [29].

As shown by a 2022 meta-analysis on large samples (a study whose authors combined and recalculated the results of many similar scientific works), the formation of an anxious attitude can be influenced by: the first negative experience of getting acquainted with mathematics (in other words, when you were unlucky with the teacher); the fact that parents are nervous about this subject and, accordingly, "wind up" the child; an excess of tests and quizzes in the curriculum (they set schoolchildren up for anxiety about the results instead of focusing them on the learning process itself). Moreover, in girls, this feeling does not disappear, even if they achieve objectively high results in their studies [20]. For example, in their studies, L. Gabey-Egozi, Y. Sheivit, M. Yesh showed the influence of teachers on the educational process, the tendency of some teachers to treat schoolchildren's focus on STEM disciplines differently for boys and girls, underestimating the successes of girls in technical sciences, overestimating the achievements of boys in them [23]. Even benevolent sexism has been shown to influence girls' emotions and motivation in mathematics, as demonstrated in two scenario experiments involving Japanese female (junior) high school students. When students imagined their math teacher commenting on a good performance with the words "well done, even though you're a girl!" (stereotype activation condition), they experienced more negative and fewer positive emotions than in the control group ("well done!") [12].

Another study noted that women who interacted with female math teachers demonstrated increased self-efficacy, greater self-esteem, and higher identification with and commitment to STEM [27].

According to experts, the so-called hidden curriculum and teaching materials can also play a certain role among the reasons for gender-differentiated socialization of schoolchildren. E. R. Yarskaya-Smirnova believes that "The hidden curriculum is, firstly, the organization of the institution itself, including gender relations at work, gender stratification of the teaching profession. Secondly, this includes the content of subjects, and thirdly, the teaching style. These three dimensions of the hidden curriculum not only reflect gender stereotypes, but also support gender inequality" [4]. It was revealed that the most significant factor in the choice of STEM disciplines by schoolgirls is also "the organization of educational life and educational programs" [23]. For example, we can cite separate training in the subject "Labor" or "Technology", division into groups in physical education lessons. Or organizing extracurricular activities for schoolchildren - community work days and festive events, where boys and girls are separated,

giving each group a different task: girls should decorate the classroom, and boys should arrange chairs [3].

The interest of girls in natural science subjects is also influenced by how these subjects are taught at school, including whether the content and design of the relevant textbooks are gender-sensitive [28]. The content of school textbooks and other teaching aids can also have a serious impact on the socialization of girls and boys.

Thus, studying the causes of gender asymmetry in STEM education of schoolchildren, modern scientists emphasize, first of all, the need for a personal approach to teaching and upbringing, to the development of the abilities of each student, regardless of gender. The problem of the gender gap in school mathematics education and STEM employment is caused by a complex of factors, including: established cultural traditions of gender stereotyping in society and in education, and methodological errors in teaching schoolchildren mathematical and natural science disciplines in general, and the gender sensitivity of girls associated with the peaks of puberty and gender-role socialization in adolescence and youth, which is not reflected and not taken into account by the pedagogical culture of modern school education [29].

Thus, the school takes a direct part in constructing “male” and “female” value orientations and behavior patterns in schoolchildren. Most girls probably understand that their life path is different from that of men, and this influences their professional choice [23]. According to EY partner (international audit and consulting corporation) and head of the Business Women program (Russia) Sofia Azizyan: “If you are taught from childhood that you are in a secondary role, that your main function is that of a mother, a wife, and only for this you are praised, even if you have five businesses, this cannot but affect” [1]. According to numerous studies conducted around the world in this area, one of the main problems that has been noted is that young girls lack positive female role models in the STEM field. A study published in the Journal of Personality and Social Psychology notes that the lack of representation and visibility of women in these fields creates a cyclical effect that can discourage women and girls from ever entering STEM. “The low representation of women in STEM perpetuates gender stereotypes of math and science as male fields and the idea that men are superior in technical and math-intensive fields.” Mackenzie Clark, a software engineer at Squarespace, says that growing up watching her mother, an electrical engineer, made her know she would be one of the few women in her field. Melina Jakoumis, a PhD candidate at the City University of New York, believes that the lack of a role model is one of the biggest obstacles women face in STEM. Pauline Cartwright, a professor of evolutionary biology at the University of Kansas, notes, “I’ve had very few personal role models in my life, mainly because there haven’t been many senior women, and I haven’t been

exposed to that.” “And I think that’s probably what’s made my life more difficult than anything else.” [16]

According to the press secretary and rector of the International University of Applied Sciences IU Erfurt (Germany) Alexandra Wuttig: "There is an urgent need for more women working in STEM who could encourage young girls [to choose a STEM specialty] with their own experience and example" [19]. Kyzybek Batyrkhanova, director of the space program in Kyrgyzstan, notes: "Our girls and women drop out of the STEM field even before they reach university. Unfortunately, our girls and women are not encouraged to build a career as an engineer or a teacher or in any other profession in the STEM field." "Both I and the girls on my team have heard demotivating things from teachers more than once, saying that we should not study physics and mathematics, but get married and take care of children. In my opinion, we need to fight this." Maral Gurbanzade (Azerbaijan), a researcher in robotics and artificial intelligence, agrees with her. “Technology and technical fields are a boys’ club, where you have to pass a test to get in… This is a common practice and it takes place in all countries of the world… And I have heard people say to me more than once: why do you need physics or science?” [25]. Gender differences in STEM education to the detriment of girls are already noticeable in the system of working with young children. Scientists believe that successful role models can help children become interested in science. Researchers at Cornell University have found that the example of successful female scientists can inspire young girls. If girls try on the role of a successful female scientist, such as Marie Sklodowska-Curie, during a game, they participate in the game longer than usual. The experiment involved 240 children aged four to seven. Girls who pretended to be Marie Curie played just as long as boys. According to Cornell University study author Reut Shachnai, “Rather than simply hearing about successful people who are worthy of emulation, it may be more beneficial for children to role-play them” [22].

Researchers from the University of Alabama and Texas Woman's University studied how role-playing games affect children's cognitive abilities. To do this, they divided preschool-age participants into three groups. With the first, a researcher played fantasy role-playing games for 15 minutes every day for five weeks, for example, pretending to fly to the moon; with the second, he played regular games; and with the third, he did not play at all, but only conducted educational activities. As a result, children from the first group, who tried on different roles every day, performed better than others in memory and flexibility of thinking tasks in a control test [22]. However, with age, girls lose interest in STEM disciplines, which is why the level of girls' participation in advanced studies is low [2]. As the results of the studies show, "gender attitudes and stereotypes inherent in everyday school life narrow the possibilities for choosing

a direction of study and a profession for both girls and boys if it does not fit into the "fairway" of normative ideas that exist in society and are recorded in the educational program" [3]. As a result, girls lose motivation, their self-confidence decreases, and they develop “imposter syndrome” [11]. Research shows that in order to equalize the self-esteem of girls and boys and overcome girls’ lack of self-confidence, it is necessary to encourage and motivate them to pursue a career in technical professions from their school years. For this purpose, STEM centers are being specially created in different countries (Finland, Estonia, Hungary, Austria, Spain, the USA, Australia) to become a motivational platform for young people to choose a future profession in the field of computer technology, demonstrating the prospects for their development in the future. The initiative, launched in 2023 by IIT Bombay, aims to introduce young girls to STEM disciplines as they approach important decisions regarding their higher education. In an attempt to address the gender disparity in STEM courses, the Indian Institute of Technology (IIT) Bombay is admitting 160 girls from Class 10, selected mostly from rural areas, to participate in various activities organised by WiSE in 2024. The courses are part of the Women in Science Engineering (WiSE) programme, specifically designed to increase interest in STEM among young girls [10].

Mentoring and mentoring programs for women are also effective strategies for encouraging girls to enter STEM fields, as developing a culture of trust and support is essential for retaining talented women and ensuring further progress towards gender equality and inclusion. Mentoring programs provide invaluable guidance from experienced mentors, and equal opportunities for leadership positions help overcome biases. Facebook COO Sheryl Sandberg notes in her bestselling book Lean In: The Power of Women, Work, and the Will to Lead that many women tend to underestimate their successes, while men tend to overestimate their own achievements. In 2013, Sandberg launched the LeanIn.Org movement, which has reached 35,000 community groups and 2 million people in 150 countries. Its goal is to encourage women to help each other, eradicating the myth that they are rivals and archenemies [1]. By prioritizing mentorship, leadership opportunities, and flexible work arrangements, employers can create a more inclusive workplace where women can drive technology and innovation on par with their male counterparts.

KPMG research shows the importance of role models – their example gives women the confidence to lead too. According to KPMG, 67% of women have learned their most important leadership lessons from other women, and 82% believe that networking with female leaders will help them advance in their careers [1].

A promising trend identified in the Ensono Speak Up 2024 survey is the emergence of female mentors leading generative AI. Nearly three-quarters (73%) of dents reported having female mentors at work who offer expertise in this area. This trend is particularly pronounced in India [6].

Some institutions of higher education have taken notice and are taking concrete steps to increase the level of mentoring and support for women entering this career. Research by Catalyst found that women are much more likely to develop other talents than men. In fact, 73 percent of women who develop talent mentor other women. This model needs to be replicated in the STEM field, starting at the earliest stages of young women's education through mentoring and guidance [21]. As a study by University of Massachusetts Amherst psychologists Nilanjana Dasgupta and Tara Dennehy showed, female engineering majors felt more confident in their abilities, professionally engaged, motivated, and less anxious when they had a female mentor. The year students spent interacting with mentors also had long-term results – female students were less likely to drop out of school and were more likely to seek out engineering jobs in the future. The researchers believe that the reason for this success is a sense of being in demand and self-confidence. As Dasgupta herself comments: "How many brilliant female minds have been lost to the natural and physical-mathematical sciences because there was no comfortable space for women there!" [1].

In the near future, at least 90% of jobs in Europe will require basic digital skills, similar to basic literacy or numeracy. However, improvements in this area are slow. The situation is made worse by the fact that 88% of workplaces do nothing to improve the digital skills of their employees, often citing the lack of digital skills and high costs as the main obstacle to solving them. Coupled with the EU's ambitious target of ensuring that at least 80% of the adult population has basic digital skills by 2030, it is clear that EU education systems, together with other actors, must contribute to achieving this goal [30]. To encourage greater participation of women in STEM fields, reduce the gender gap in scientific and technical fields, increase female employment rates and ensure economic independence in Italy, there is a Regional DSU (Diritto allo Studio Universitario) Scholarship for students, providing free education, accommodation, food and an allowance of around €6,500 per year [7]. The British Council is now running a scholarship programme in partnership with UK universities to help women from around the world [26]. On 7 August 2024, the UK announced the first 10 recipients of the ASEAN-UK SAGE Women in STEM Scholarships. The new scholarship programme aims to eliminate gender inequalities in access to education and careers in science, technology, engineering and

mathematics (STEM) in ASEAN countries and Timor-Leste [18]. In addition, there are numerous School and University Scholarships to encourage more women into STEM fields [24].

As highlighted in the 2024 Ensono Speak Up survey, inequality between women in the tech industry persists. Balancing caregiving responsibilities with personal work remains a challenge for half of the women surveyed, with a quarter reporting discomfort or insecurity due to microaggressions or discrimination in the workplace. The survey highlights the importance of flexibility in work organization: dent express a desire to have the freedom to choose where they work. Offering flexible working hours and remote work options are becoming key strategies for retaining top talent [6].

Conclusions.

The main conclusion of the study is that it is worth creating a special set of measures to encourage girls to study mathematics and natural sciences at a young age, due to the fact that, according to data from all countries, women researchers in the fields of science, technology, engineering and mathematics are less represented [6].

A study of international experience shows that the demand for professions related to artificial intelligence, big data analysis, programming, robotics, and cybernetics is steadily growing worldwide. A comprehensive approach to addressing the gender imbalance in STEM fields could lead to significant improvements. A 2010 academic study of group intelligence found that the collective intelligence of a work group depends on three factors: the average social sensitivity of group members, the ability of group members to contribute to the common cause in turn, and the proportion of women in the group. Groups that included at least one woman outperformed all-male groups on a test of collective intelligence, and group intelligence was found to be more strongly associated with gender diversity than with the IQ of individual team members [14]. This process actualizes the problem of reducing the gender imbalance in STEM, requires the involvement of the state, the scientific community, business, and public organizations in the full use of women's talents and leadership, creating a set of measures that encourage girls to study mathematics and natural sciences at school age. Adaptation of successful foreign practices to national conditions can play a major role in this.

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