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GENDER ENROLLMENT PATTERNS IN A UNIVERSITY IN KAZAKHSTAN: A 2020-2024 ANALYSIS OF STEM AND NON-STEM DISCIPLINES

Abstract. This study explores gender enrollment patterns in STEM and non-STEM disciplines at a university in Kazakhstan from 2020 to 2024, examining evolving gender dynamics in higher education. Using longitudinal data on enrollment, gender ratios, and Unified National Test (UNT) scores, the analysis reveals persistent gender disparities. Female enrollment in STEM fields remained stable at approximately 34% throughout the study period, contrasting with higher but gradually declining female participation in non-STEM fields, which decreased from 74.8% in 2020 to 68.9% in 2024. Despite statistical significance in changes across both STEM and non-STEM fields, the practical significance of these shifts is minimal, highlighting the challenges of addressing gender imbalances in STEM. Factors such as cultural norms, limited female role models, and curriculum biases are discussed as contributors to the disparity. This research emphasizes the need for targeted interventions and inclusive policies to foster greater female participation and retention in STEM disciplines. The findings also underscore the economic and societal relevance of equitable education, offering actionable insights for policymakers and educators to promote gender equity in Kazakhstan's higher education system. Ultimately, this study contributes to the broader discourse on gender dynamics in education, particularly in the context of Central Asia.

Keywords: gender disparities, gender equity, enrollment trends, STEM education, higher education.

Introduction

This study considers the evolving gender dynamics in higher education within a specific Kazakhstani university. By examining enrollment trends in STEM (Science, Technology, Engineering, and Mathematics) and non-STEM disciplines over the period from 2020 to 2024, the research sheds light on critical issues of representation. The findings go beyond academic interest, offering valuable insights that could shape educational policies, institutional strategies, and societal attitudes towards gender equity in one of Central Asia's key educational institutions.

Kazakhstan's focus on educational reform and technological innovation provides a compelling backdrop for exploring gender disparities in university enrollments. While women comprise 53% of researchers overall, they represent less than 45% in STEM fields (Tsakalerou, 2022). As the country seeks to diversify its economy and improve its standing in global innovation indices, addressing gender imbalances in higher education—particularly in STEM disciplines—becomes essential. This study is timely and relevant, not only identifying current trends but also contributing to the development of inclusive educational and career opportunities. By doing so, it aims to help ensure that Kazakhstan's future workforce reflects the diverse talents of its population.

Gender disparities in education are a well-documented global phenomenon, yet the case of Kazakhstan introduces unique regional and cultural dimensions. While women dominate in public education and higher education institutions (Kredina et al., 2023), there is gender inequality in postgraduate education, with more women than men pursuing advanced degrees (Satpayeva & Nygymetov, 2023). Factors such as cultural norms, curriculum biases, and limited female role models in STEM careers contribute to this imbalance. Conversely, many non-STEM disciplines have either achieved gender parity or, in some cases, seen higher female participation. By examining these trends at the university level, this study provides a focused view that mirrors broader national and regional dynamics.

The primary objective of this study is to conduct a detailed longitudinal analysis of gender enrollment trends from 2020 to 2024 in STEM and non-STEM disciplines at a Kazakhstani university. Its contributions are wide-ranging, offering empirical insights by documenting enrollment patterns and providing a robust foundation for future research on gender dynamics in higher education. The findings also present actionable strategies for policymakers to address gender disparities within the Kazakhstani context and guide universities in designing inclusive educational approaches that align with local cultural and academic settings. Additionally, the study emphasizes the economic relevance of equitable education by highlighting how gender imbalances may impact Kazakhstan's competitiveness in key industries, reinforcing the broader significance of fostering gender equity in higher education.

Literature Review

Overview of Existing Studies on Gender Disparities in Education

Numerous studies have highlighted the persistent gender disparities within educational settings. For instance, Jacobs (1996) examined the historical trends in gender differences in college enrollment, noting that women have increasingly outnumbered men in higher education overall. However, this trend does not uniformly apply across all disciplines. Despite women's increased participation in higher education, they remain underrepresented in prestigious STEM fields, particularly engineering and computer science (Bystydzienski, 2020; Mullen & Baker, 2015). This gender gap persists due to various factors, including hostile academic climates, exclusionary practices, and subtle discrimination in hiring and promotion (Bystydzienski, 2020). Gender segregation in fields of study persists across different types of universities, with women underrepresented in prestigious fields like engineering and computer science (Jacobs, 1996; Liu, 2024). Cultural stereotypes about these fields, such as social isolation and male-orientation, act as gatekeepers, deterring girls from pursuing these careers (Cheryan et al., 2015). The underrepresentation of women in engineering and computing is significant, as diversity in the workforce contributes to creativity, productivity, and innovation (Corbett, 2015). Conversely, fields traditionally dominated by women, such as education and nursing, continue to see higher female enrollments (Sax, 2001). These studies underscore the complex nature of gender dynamics in education, influenced by cultural, social, and institutional factors.

Focus on Trends in STEM and Non-STEM Enrollments

Recent research has highlighted trends in STEM and non-STEM enrollments and persistence. Predictive analytics using middle school math software interactions can distinguish future STEM majors with 66% accuracy (Pedro et al., 2014). Factors influencing STEM retention include financial aid, demographics, and academic performance, with concerns about the underrepresentation of women and minorities (Whalen & Shelley, 2010). Cross-country analysis reveals that R&D expenditures positively impact STEM enrollments, while population density and expected years of schooling have negative effects (Bruno & Faggini, 2021). For on-campus students, noncognitive factors like academic self-efficacy and degree aspiration positively affect STEM persistence, while academic performance is crucial for both STEM and non-STEM retention (Gansemer-Topf et al., 2017).

Beede et al. (2011) reported that while women's participation in STEM has grown, the rate of increase has not kept pace with that in non-STEM fields, leading to a widening gender gap in STEM disciplines. Hill, Corbett, and St. Rose (2010) further explored why this gap exists, pointing to factors like lack of early encouragement, societal stereotypes, and the chilly climate in some STEM departments. On the other hand, research by Ceci, Williams, and Barnett (2009) suggests that in some non-STEM areas like humanities, women's enrollment has reached or exceeded parity with men. This discrepancy illustrates not just a field-specific gender divide but also the variability in growth rates between different educational sectors.

Gaps in the Current Literature That the Study Aims to Address

While much research has been dedicated to understanding gender enrollment trends, there are notable gaps that the current study aims to address. Firstly, there is a lack of longitudinal data that specifically compares the growth rates of male and female enrollments across both STEM and non-STEM fields over recent decades. Secondly, many studies focus on either STEM or non-STEM exclusively without a comparative analysis that could shed light on why disparities might occur differently in these areas. Lastly, the interaction between gender and other demographic variables like ethnicity or socioeconomic status in enrollment trends is often underexplored. The research question, "Are there significant differences in the growth rates of male and female enrollments in STEM and Non-STEM fields from 2020 to 2024?", seeks to bridge these gaps by providing a comprehensive analysis of these trends, potentially offering insights into policy and educational strategies to mitigate gender disparities in higher education.

Methodology

Data Sources and Preparation

Table 1. Annual Enrollment and UNT Metrics (2020-2024*)*

Year	Total enrollment	Female enrollment	Male enrollment	STEM enrollment	non-STEM enrollment	Average UNT scores
2020	2081	1171	910	959	1122	94
2021	2239	1259	980	960	1279	104
2022	2388	1403	985	947	1441	102
2023	2504	1336	1168	955	1549	104
2024	2351	1417	934	579	1772	107

The datasets used in this study were sourced from enrollment records of a university in Kazakhstan, covering the academic years from 2020 to 2024. These records include data on total enrollments, gender, Unified National Test (UNT) scores, and the departments students enrolled in. The STEM specializations include fields such as Computer Science, Information Systems, Mathematics, and Statistics, while Non-STEM specializations encompass disciplines such as language and math education, law, economics, and international relations.

The data was organized to examine the trends in gender-specific enrollments and academic preparedness, as reflected by the UNT scores, across both STEM and Non-STEM fields. The data preparation process involved categorizing students into their respective fields (STEM or Non-STEM) and computing average UNT scores for each year. This data is summarized in Table 1: Annual Enrollment and UNT Metrics (2020-2024), which presents the total, female, male, STEM, and Non-STEM enrollment counts, as well as the average UNT scores for each year.

For visual representation, Figure 1 illustrates the total enrollment statistics and dynamics by gender, while Figure 2 highlights the trends in STEM and Non-STEM enrollments alongside the average UNT scores over the study period. These visual aids help in understanding the underlying patterns of gender disparity and academic achievement within the university's enrollment landscape.

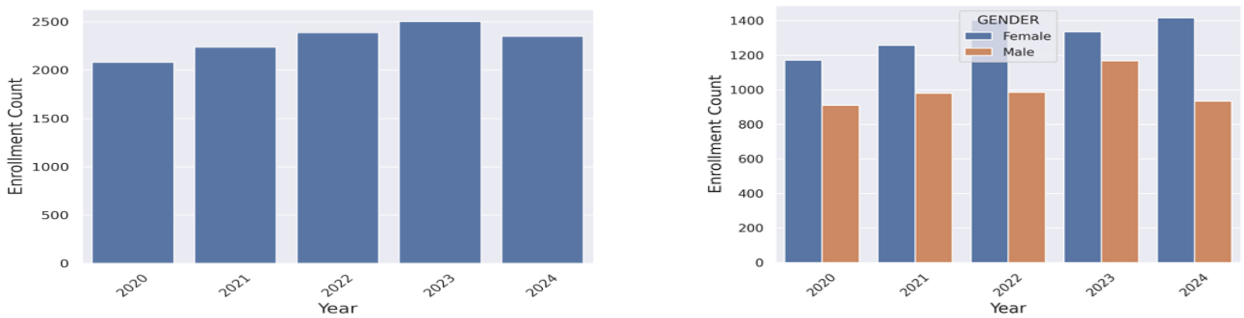


Figure 1- Total enrollment statistics and enrollment dynamics according to gender

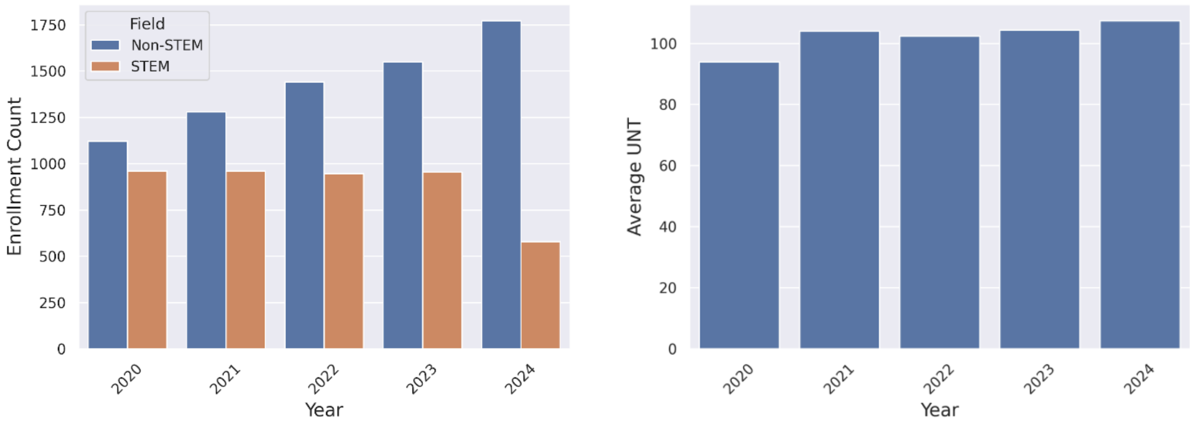


Figure 2- STEM and non-STEM enrollment dynamics and average UNT scores

Statistical Analysis

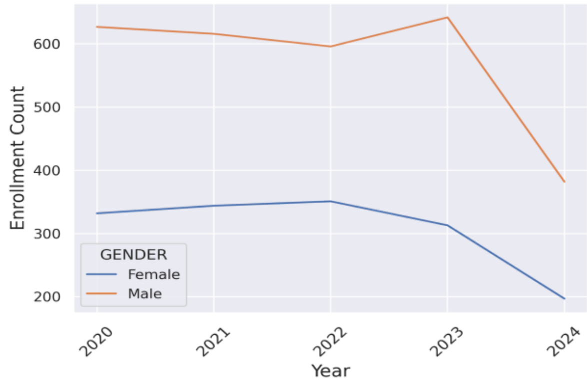
To test whether there was a statistically significant change in the female and male enrollment ratios in STEM and non-STEM fields over the years, we first conducted normality tests using the Shapiro-Wilk test for both female and male ratios in each field. This test checks whether the distributions of the ratios follow a normal distribution. The results showed that both the female and male ratios in STEM and non-STEM fields followed normal distributions (p-values for both female and male ratios in both fields were above 0.05, indicating normality). After confirming normality, we proceeded with paired t-tests to compare the means of the female and male enrollment ratios across the five years. The paired t-test was chosen because it is suitable for comparing two related samples, in this case, the female and male ratios over the same years. A p-value threshold of 0.05 was used to determine statistical significance.

Additionally, we analyzed trends in female enrollment rates in STEM and non-STEM fields. In STEM fields, the female ratio remained relatively stable over the years, while in non-STEM fields, the female ratio showed a steady decline. The observed changes, while statistically significant, appeared to have minimal practical significance, particularly in STEM, where the female enrollment ratio showed only small fluctuations despite statistical significance. In non-STEM fields, although the female enrollment ratio decreased over time, the magnitude of change was modest, underscoring the distinction between statistical significance and practical significance.

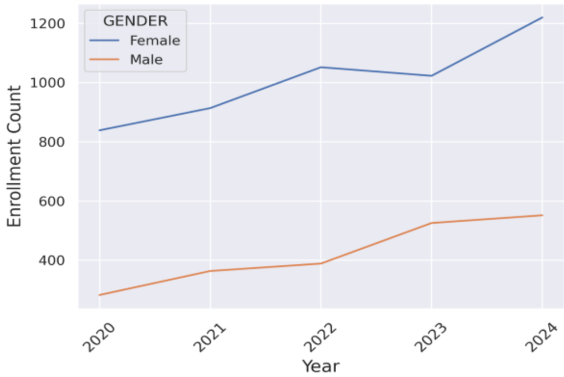
The analysis also focused on the comparison of gender distributions between STEM and non-STEM fields, specifically in 2024. This was done through descriptive statistics and comparisons of the female and male enrollment ratios across the two disciplines. These comparisons highlighted the significant gender disparities in STEM versus non-STEM fields, with female enrollment in STEM remaining at approximately 34%, while female enrollment in non-STEM fields was much higher, although it decreased over time.

Findings

Figure 3(A) presents the trends in STEM enrollment by gender from 2020 to 2024. Over this period, male enrollment consistently outnumbered female enrollment. The data shows a relatively steady trend for male students, with the highest number of male enrollments in 2023 (642), while female enrollments saw a gradual decline from 2020 to 2024, with a significant drop in 2024 (197). The decreasing trend for female students in STEM disciplines raises concerns about potential attrition and the need for interventions to retain female students in these fields. In contrast, Figure 3(B) highlights the trends in non-STEM enrollment by gender over the same period. Female enrollments in non-STEM specialties have steadily increased, reaching 1220 in 2024, showing a positive growth trajectory. Meanwhile, male enrollments also grew, but at a slower pace compared to female enrollments, peaking at 552 in 2024. The rising number of female enrollments in non-STEM fields suggests an increasing shift toward these disciplines, highlighting the evolving landscape of gender dynamics in higher education. Together, these figures underscore the contrasting enrollment patterns in STEM and non-STEM fields, with a notable gender imbalance in STEM that warrants further investigation.



(A) STEM enrollments



(B) Non-STEM enrollments

Figure 3- Female vs male enrollment in STEM and non-STEM specialties (2020-2024), respectively.

Table 2 presents the ratios of female and male student enrollments in STEM and non-STEM specialties. The Shapiro-Wilk test results showed that both the female and male enrollment ratios in STEM fields followed normal distributions, as evidenced by the high p-values (0.9818 for both ratios). Subsequently, a paired t-test was conducted to evaluate whether there was a statistically significant difference between the female and male enrollment ratios over the years. The t-test results revealed a highly significant difference, with a t-statistic of -20.49 and a p-value of 3.35e-05, which is well below the 0.05 threshold. This indicates that the female and male enrollment ratios in STEM fields have changed significantly over the years. Specifically, the data suggests a trend where the male enrollment ratio has been consistently higher than the female ratio, and this difference has remained statistically significant throughout the study period.

Table 2. Female vs male enrollment ratios for STEM and non-STEM specialties (2020-2024).

Year	STEM		non-STEM	
	Female ratio	Male ratio	Female ratio	Male ratio
2020	34.6%	65.4%	74.8%	25.2%
2021	35.8%	54.2%	71.5%	28.5%
2022	37.1%	62.9%	73.0%	27.0%
2023	32.8%	67.3%	66.0%	34.0%
2024	34.0%	66.0%	68.9%	31.1%

The table presenting the female and male enrollment ratios for Non-STEM fields from 2020 to 2024 shows that the female ratio has fluctuated over the years, starting at 0.747 in 2020, dipping to 0.660 in 2023, and then recovering slightly to 0.688 in 2024. The male ratio, conversely, has shown a corresponding inverse trend, with a decrease in the female ratio resulting in an increase in the male ratio. The Shapiro-Wilk test results indicate that both the female and male ratios follow normal distributions, with p-values of 0.896, suggesting no deviation from normality. A paired t-test was then conducted to assess whether the changes in the ratios over the years were statistically significant. The test yielded a t-statistic of 13.50 and a p-value of 0.00017, indicating a highly significant difference between the female and male ratios in non-STEM fields over the years.

Table 2 compares female enrollment ratios in STEM and non-STEM fields from 2020 to 2024. In STEM fields, the female enrollment ratio consistently hovers around 34%, with minor fluctuations between 32.8% in 2023 and 37.1% in 2022. In contrast, the female enrollment ratio in non-STEM fields is significantly higher, starting at 74.8% in 2020 and gradually declining to 68.9% by 2024. Over time, the female ratio in non-STEM fields shows a noticeable decrease, while the ratio in STEM remains relatively unchanged. The male enrollment ratio in STEM fields has remained higher than the female ratio, whereas in Non-STEM fields, the male enrollment ratio has increased from 25.2% in 2020 to 31.1% in 2024.

Discussion

The comparison of female enrollment rates in STEM versus non-STEM fields reveals a stark contrast in gender representation. While female enrollment in STEM remains stable at around 34% across the five years, the female enrollment ratio in non-STEM fields is significantly higher, starting at 74.8% in 2020 and gradually declining over time to 68.9% in 2024. This decline in non-STEM female enrollment suggests a shifting trend in women’s participation in non-technical fields, although it remains markedly higher than in STEM disciplines. On the other hand, the stability in the female ratio in STEM reflects a persistent gender gap in technical disciplines, with minimal improvement in female representation despite fluctuations in the data. These trends highlight the ongoing challenges in achieving gender equity in STEM education, where women continue to be underrepresented compared to non-STEM fields. Further efforts may be necessary to address the gender imbalance in STEM and support greater female participation in these areas.

Although the paired t-test indicates a statistically significant difference in the female and male enrollment ratios in STEM fields over the years (with a p-value well below the 0.05 threshold), the practical significance of this result appears minimal. The observed changes in the female ratio from 0.345 in 2020 to 0.340 in 2024 are relatively small, suggesting that the gender gap in STEM enrollments has remained fairly consistent over the study period. Despite the statistical significance, the magnitude of the difference is minor, and the trends do not indicate a substantial shift in the gender balance. This highlights the distinction between statistical significance and practical significance, where even small differences can be statistically significant in a paired t-test, but the actual change in the enrollment ratios may not be meaningful in real-world terms. Therefore, while the result is significant from a statistical perspective, the practical implications for addressing gender disparities in STEM may require more pronounced shifts.

Similarly, although the paired t-test suggests a statistically significant difference in the female and male enrollment ratios in non-STEM fields (p-value = 0.00017), the observed changes in the ratios appear relatively modest in practical terms. The female ratio decreased from 0.747 in 2020 to 0.688 in 2024, while the male ratio increased correspondingly from 0.252 to 0.312. These changes, while statistically significant, do not represent large shifts in the gender distribution of non-STEM enrollments. The result underscores the importance of distinguishing between statistical significance and practical significance. While small differences over time can lead to significant test outcomes, the overall trends in enrollment ratios remain relatively stable, with no substantial reversal or dramatic change in gender representation. This suggests that, despite the statistical evidence, the actual gender dynamics in non-STEM fields have not changed drastically in recent years.

Conclusion

In conclusion, this study provides valuable insights into the gender dynamics of university enrollments in Kazakhstan, particularly in STEM and non-STEM disciplines, over the period from 2020 to 2025. The findings underscore persistent gender disparities, with female representation in STEM remaining relatively stable around 34%, while non-STEM fields show a gradual decline in female enrollment ratios. Despite statistically significant changes in both STEM and non-STEM enrollments, the practical significance of these shifts appears minimal. This highlights the importance of distinguishing between statistical significance and real-world impact. The results suggest that while gender imbalances in STEM persist, attention to targeted interventions and continued efforts are necessary to address the underrepresentation of women in these critical fields. Moreover, the findings encourage a broader discussion on the changing trends in non-STEM fields and the evolving landscape of gender roles in higher education. Ultimately, the study calls for greater focus on creating inclusive educational environments that foster greater participation and retention of women in STEM disciplines, alongside addressing the complex dynamics in non-STEM fields.

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ҚАЗАҚСТАН УНИВЕРСИТЕТІНЕ ТҮСУДІҢ ГЕНДЕРЛІК ЗАҢДЫЛЫҚТАРЫ: 2020-2024 ЖЫЛДАРДАҒЫ STEM ЖӘНЕ STEM ЕМЕС ПӘНДЕРДІ ТАЛДАУ

Аңдатпа. Бұл зерттеу Жоғары білім динамикасындағы өзгерістерді анықтай отырып, 2020-2024 жылдар аралығындағы Қазақстан университеттерінің бірінде STEM-білімге және STEM емес-пәндерге қабылдау үлгілеріндегі гендерлік диспропорцияларды зерттеуге арналған. Қабылдау, гендерлік қатынастар және Ұлттық бірыңғай тестілеу (ҰБТ) ұпайлары туралы мәліметтерге негізделген талдау гендерлік теңгерімсіздіктің сақталуын көрсетеді. STEM пәндеріндегі әйелдердің үлесі зерттеу кезеңінде шамамен 34% деңгейінде Тұрақты болып қалды, ал STEM емес пәндерге әйелдердің қатысуы бастапқыда жоғары болды, 2020 жылы 74,8%-дан 2024 жылы 68,9%-ға дейін төмендеді. Қабылдау үрдістеріндегі статистикалық маңызды өзгерістерге қарамастан, олардың практикалық маңызы шектеулі, бұл STEM-де гендерлік теңдікке қол жеткізу мәселесін шешудің қиындығын көрсетеді. Теңгерімсіздікке ықпал ететін факторлардың ішінде мәдени нормалар, әйелдердің рөлдік модельдерінің болмауы және оқу бағдарламаларының ерекшеліктері ерекшеленеді. Зерттеу гендерлік теңдікті ілгерілету және әйелдердің STEM пәндеріне қатысуын арттыру үшін мақсатты араласулар мен инклюзивті саясаттардың қажеттілігін көрсетеді. Нәтижелер саясаткерлер мен білім беру мекемелеріне практикалық нұсқаулар ұсына отырып, экономикалық даму мен әлеуметтік прогреске кеңірек әсер етеді.

Түйін сөздер: гендерлік теңсіздік, гендерлік теңдік, қабылдау үрдістері, STEM-білім, жоғары білім.

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ГЕНДЕРНЫЕ ЗАКОНОМЕРНОСТИ ЗАЧИСЛЕНИЯ В УНИВЕРСИТЕТЕ КАЗАХСТАНА: АНАЛИЗ STEM И НЕ-STEM ДИСЦИПЛИН ЗА 2020-2024 ГОДЫ

Абстракт. Данное исследование посвящено изучению гендерных диспропорций в паттернах зачисления на STEM-образование и не-STEM-дисциплины в одном из университетов Казахстана за период с 2020 по 2024 год, выявляя изменения в динамике высшего образования. Анализ, основанный на данных о зачислении, гендерных соотношениях и баллах Единого национального тестирования (ЕНТ), показывает сохраняющийся гендерный дисбаланс. Доля женщин в STEM-дисциплинах оставалась стабильной на уровне около 34% в течение всего периода исследования, в то время как участие женщин в не-STEM-дисциплинах, изначально более высокое, снизилось с 74,8% в 2020 году до 68,9% в 2024 году. Несмотря на статистически значимые изменения в тенденциях зачисления, их практическое значение ограничено, что подчеркивает сложность решения проблемы достижения гендерного равенства в STEM. Среди факторов, способствующих дисбалансу, выделяются культурные нормы, недостаток женских ролевых моделей и особенности учебных программ. Исследование подчеркивает необходимость целевых интервенций и инклюзивных политик для продвижения гендерного равенства и увеличения участия женщин в STEM-дисциплинах. Результаты имеют более широкие последствия для экономического развития и социального прогресса, предлагая практические рекомендации для политиков и образовательных учреждений.

Ключевые слова: гендерные диспропорции, гендерное равенство, тенденции зачисления, STEM-образование, высшее образование.

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