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Gender Inequality in STEM: Socialization, Structural Barriers, and Institutional Dynamics in the Republic of North Macedonia

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Abstract

Gender equality constitutes both a fundamental human right and a central pillar of sustainable socio-economic development (Gjorgjioska et al., 2025). Despite notable gains in educational attainment, gender disparities remain pronounced in Science, Technology, Engineering, and Mathematics (STEM), particularly in pathways leading to technical leadership. This study explores the "Southeast European Paradox," whereby countries such as North Macedonia and Serbia record substantially higher shares of female STEM graduates than the European Union average, yet struggle to retain this talent within the labor market (OECD, 2024).

Adopting a mixed-methods analytical approach, the research interprets these patterns through the theoretical lenses of social identity theory, social constructivism, and feminist institutionalism. The findings point to a persistent "leaky pipeline": although women in North Macedonia perform strongly in tertiary education, a significant proportion subsequently exit STEM careers. This attrition is closely associated with exclusionary institutional environments, gendered perceptions of technical competence, and limited career progression opportunities. Comparative evidence from neighboring Southeast European contexts further indicates enduring sectoral segregation, with women underrepresented in high-value industrial domains relative to service-oriented sectors.

The study concludes that formally gender-neutral policy frameworks are insufficient to address these structural constraints. Instead, more robust and targeted interventions are required, including institutional accountability mechanisms such as Gender Responsive Budgeting, enforceable organizational quotas, and systematic gender-sensitivity training within educational and professional settings.

Keywords: Gender inequality, STEM, Southeast Europe, institutional barriers, gender responsive budgeting.

Introduction

Gender equality is a cornerstone of modern global policy, recognized as a prerequisite for innovation, economic competitiveness, and democratic governance (Sjoberg, 2023). Within Science, Technology, Engineering, and Mathematics, however, a persistent "leaky pipeline" continues to diminish female representation as careers progress (van Anders, 2004). While this phenomenon is documented globally, Southeast Europe presents a distinctive socio-political paradox. In North Macedonia, for instance, women represent 47.8% of STEM tertiary graduates, one of the highest rates in the region (Tereshchenko et al., 2023). Yet, this educational success does not translate into labor market parity, as nearly 70% of these women eventually exit the sector due to systemic institutional barriers and workplace prejudice (Reka & Memeti, 2024).

The persistence of this gap cannot be attributed to a lack of academic ability or individual preference alone (González-Pérez et al., 2022). Regional data indicate that female students often outperform their male peers in mathematics, yet they face a "chilly climate" where their technical competence is frequently questioned (Ferati et al., 2023). This is evidenced by the fact that only 12% of men in the Western Balkans view their female colleagues' computer skills positively, highlighting a deep-seated cultural coding of STEM as a masculine domain (Ferati et al., 2023; Leka et al., 2024). Consequently, the disparity is not merely a product of "choice" but is actively produced through the interaction of gender socialization, institutional "gender regimes," and restrictive labor market structures (Anglin et al., 2022; Baguant et al., 2023).

This paper investigates the mechanisms sustaining these inequalities by integrating four theoretical perspectives: gender role theory, social identity theory, social constructivism, and feminist institutionalism (Dost, 2024; Vilhena & Pizarro, 2021). Focusing on North Macedonia, the study situated within the broader Southeast European context aims to explain why high graduation rates fail to overcome the structural "glass ceilings" and "identity dissonance" that characterize the regional STEM landscape (Cotter et al., 2001; Dost, 2024). By combining theoretical analysis with regional statistics, the study provides a framework for multi-level policy interventions that go beyond increasing educational access to address the substantive conditions of career advancement.

Conceptual and Theoretical Framework

The concept of equality in STEM has evolved from classical discussions of resource distribution to a more nuanced focus on structural barriers. While formal equality—treating everyone the same—is often the baseline for policy, it is frequently insufficient in technical fields because the starting points for men and women are inherently different. Instead, an equity lens is required to address the "leaky pipeline," recognizing that women need specific institutional support to overcome barriers that increase in complexity as they move up the academic and professional ladder (Guo et al., 2025). In the post-socialist context of North Macedonia, this distinction is critical: while formal legal equality is high, persistent cultural narratives and a "masculine career model" continue to shape actual outcomes (Ferati et al., 2023; Reka & Memeti, 2024).

To explain these disparities, this study adopts an interdisciplinary framework integrating four complementary perspectives:

Gender Role Theory and Socialization - Gender role theory posits that societies develop normative assumptions regarding appropriate roles for men and women, which are transmitted through early socialization in families and schools (Anglin et al., 2022). In STEM, these roles are often internalized as implicit beliefs about one's own abilities (Aalderen-Smeets & Molen, 2016). Cultural narratives frequently link scientific competence and technical expertise with masculine traits, discouraging women from pursuing these disciplines even when their academic performance equals or exceeds that of their male peers (Anglin et al., 2022; Ferati et al., 2023).

Social Constructivism and Gender Regimes - Building on the concept of gender as a socially constructed phenomenon, this study examines how educational and professional environments actively reproduce gendered norms (Baguant et al., 2023). Gender is not merely a biological attribute but is "done" through everyday interactions, evaluation systems, and workplace cultures (Guo et al., 2025). Within STEM departments, these "gender regimes" can reinforce the association of leadership with masculinity, influencing how institutional actors evaluate competence and suitability for advancement (Baguant et al., 2023; Bairoh, 2023).

Social Identity Theory and "Belonging" - Social identity theory explains how group membership influences motivation and persistence. When STEM fields are culturally coded as masculine, women may experience a "lack of identity fit" or reduced feelings of belonging (Dost, 2024). This dissonance is exacerbated by peer perceptions; for instance, in the Western Balkans, research indicates that only 12%

of men view their female colleagues' computer skills positively, creating a "chilly climate" that discourages long-term career commitment despite proven technical excellence (Ferati et al., 2023; Leka et al., 2024).

Feminist Institutionalism - Finally, feminist institutionalism highlights how organizational rules and informal norms reproduce inequality even in the absence of explicit discrimination (Vilhena & Pizarro, 2021). Institutional arrangements such as recruitment practices and promotion criteria often favor a career trajectory that neglects the need for co-responsibility in care work (Reka & Memeti, 2024). This perspective emphasizes that formal access to education does not automatically translate into substantive equality in leadership, as the "glass ceiling" is maintained through gendered structural conditions and organizational practices (Cotter et al., 2001; Vilhena & Pizarro, 2021).

By integrating these perspectives, the study demonstrates that gender inequality in STEM is a systemic phenomenon emerging from the interaction of individual attitudes, socio-cultural norms, and institutional frameworks (Ferati et al., 2023; Vilhena & Pizarro, 2021).

Research Strategy and Analytical Approach

The study employs a data triangulation strategy, integrating quantitative indicators with theoretically informed qualitative interpretation and primary fieldwork findings (Reka & Memeti, 2024). The analytical approach is explanatory rather than purely descriptive (Reka & Memeti, 2024). Quantitative data establish empirical trends—such as participation rates and career progression—while qualitative frameworks, including gender role theory and social identity theory, are applied to interpret the causal mechanisms driving these patterns (Anglin et al., 2022; Dost, 2024).

Case Selection and Comparative Framework - North Macedonia serves as the primary case study due to its notably high proportion of female STEM graduates alongside persistent labor market disparities (Reka & Memeti, 2024). To contextualize these dynamics, the study incorporates a comparative regional perspective, including Serbia, Croatia, and Bulgaria (Ferati et al., 2023; Tereshchenko et al., 2023). These countries were selected based on shared post-socialist institutional legacies, comparable higher education structures, and similar trajectories of European integration (Ferati et al., 2023; Reka & Memeti, 2024).

Data Sources and Methodology - The empirical component draws on internationally harmonized statistical systems and complementary qualitative insights, integrating secondary data from Eurostat, the UNESCO Institute for Statistics, the OECD, and the European Commission's *She Figures* framework. These sources ensure cross-national comparability and methodological consistency through the application of standardized classifications (e.g., ISCED, Frascati) and coordinated international data collection protocols (European Commission, 2021; OECD, 2015; UNESCO Institute for Statistics, 2023; Eurostat, 2022). Primary qualitative synthesis to capture the "on-the-ground" dynamics of policy influence, the analysis synthesizes results from a survey of 10–15 activists and professionals within the North Macedonian STEM sector (Reka & Memeti, 2024). This allows the study to identify specific "change agents" and the practical barriers faced by those advocating for gender mainstreaming (Reka & Memeti, 2024).

Policy Document Review: A desktop analysis of National Action Plans for Gender Equality and national legislative frameworks was conducted to evaluate the alignment between policy intent and structural outcomes (Reka & Memeti, 2024). Three categories of indicators are examined across the selected regions: educational participation - Enrollment and graduation rates in tertiary STEM programs (Reka & Memeti, 2024). Labor market representation: participation in engineering, ICT, and scientific research occupations (Reka & Memeti, 2024). Career advancement - the presence of women in senior academic, managerial, and leadership positions, addressing the "glass ceiling" in higher education (Reka & Memeti, 2024; Vilhena & Pizarro, 2021).

Theoretical Integration: the interpretation of empirical patterns is guided by an integrated framework that combines Gender Role Theory: Micro level socialization and career choice (Anglin et al., 2022).

Social Identity Theory: Perceptions of belonging and "identity fit" in male-dominated spaces (Dost, 2024). Feminist Institutionalism: Structural and organizational dynamics that maintain gendered power imbalances (Vilhena & Pizarro, 2021).

Several limitations are acknowledged. While the inclusion of survey data provides qualitative depth, the small sample size (10–15 respondents) means these findings are indicative rather than representative of the entire workforce (Reka & Memeti, 2024). Furthermore, variations in national statistical methodologies across the Western Balkans may affect the comparability of certain secondary indicators (Ferati et al., 2023). Despite these constraints, this integrative methodological

approach provides a robust framework for understanding the structural drivers of gender inequality in STEM.

Gender Socialization and Educational Pathways

Gender socialization plays a crucial role in shaping educational aspirations and career choices (Özdemir & As, 2022). From an early age, social norms and expectations influence how boys and girls perceive their abilities and future opportunities (Arel, 2014; Hamel, 2021). Research shows that stereotypes associating mathematics, engineering, and technology with masculine identities often emerge during early childhood and continue to influence educational choices throughout adolescence (Cvencek et al., 2011; McGuire et al., 2022).

Family expectations, media representations, and educational environments contribute to the internalization of these stereotypes (Cheryan et al., 2017; Wang & Degol, 2017). Girls may develop lower self-confidence in technical subjects despite demonstrating comparable academic performance to boys (OECD, 2015; UNESCO, 2017). The limited visibility of female role models in STEM professions can further reinforce perceptions that these careers are less suitable for women (Dasgupta & Stout, 2014; Lockwood, 2006). Female student representation in a course significantly predicts greater academic achievement for *all* students, with particularly favorable outcomes for women in mathematics and computer science when they have a female instructor (Bowman et al., 2022)."Lack of Identity Fit" to explain why even high-achieving girls might opt out. It's not just about competence; it's about whether they see themselves as belonging in a "male-coded" environment (Bowman et al., 2022). Stereotype Threat: Although Steele & Aronson are in your bibliography, you can more explicitly link it to your findings on why women in North Macedonia might achieve higher grades but still have lower self-confidence in technical fields (Verdugo-Castro et al., 2022). Educational institutions can unintentionally reinforce these patterns through curriculum design, teaching practices, and career guidance structures (OECD, 2019; UNESCO, 2017). Teachers' expectations and classroom dynamics may also influence students' perceptions of their abilities in science and mathematics (Gunderson et al., 2012; Wang & Degol, 2017).

As a result, gender disparities in STEM often originate during early educational stages rather than emerging exclusively in labor market contexts (Eccles, 2011; Cheryan et al., 2017).

Structural Barriers in STEM Careers

Although gender gaps in higher education have narrowed significantly in many countries, structural barriers continue to affect women's advancement in STEM careers (European Commission, 2021; World Economic Forum, 2023). One of the most widely discussed phenomena in this context is the "glass ceiling," which refers to invisible organizational barriers that prevent women from reaching senior leadership positions despite comparable qualifications and professional achievements (Cotter et al., 2001).

Institutional practices such as opaque promotion procedures, limited mentoring opportunities, and expectations regarding long working hours can disproportionately affect women's career trajectories (Mason et al., 2013; OECD, 2019). Work-life balance challenges, particularly related to family responsibilities, may further contribute to unequal career progression (European Institute for Gender Equality, 2022; UNESCO, 2017). These fields often have a much higher male-to-female ratio (around 4:1) compared to other STEM disciplines (Cimpian & King, 2024). Highlighting this shows that the "STEM" umbrella can sometimes mask the more extreme disparities in certain technical disciplines. The COVID-19 pandemic exacerbated existing disparities by leading to lower initiation of new projects, which could impact the productivity and careers of women in STEM for years to come (Figueiredo, 2023).

Organizational cultures within scientific institutions and technology industries may also reproduce gender biases in evaluation and leadership selection processes (Acker, 1990; Ridgeway, 2011). These dynamics can result in the systematic undervaluation of women's professional contributions and limit their access to decision-making positions (Eagly & Karau, 2002; Valian, 1998). Consequently, structural inequalities within organizational environments play a crucial role in shaping gender disparities in STEM professions (European Commission, 2021; World Economic Forum, 2023).

Comparative Regional Evidence: The Southeast European Paradox

A comparative analysis of Southeast Europe reveals a distinctive "STEM Paradox": the region consistently produces higher proportions of female STEM graduates than the Western European average, yet fails to convert this educational capital into professional leadership (Ferati et al., 2023; Tereshchenko et al., 2023). While the European Union average for female STEM graduates stands at 32.2%, several

countries in the region significantly exceed this benchmark (OECD, 2024). For instance, North Macedonia (44.5%) and Serbia (43.5%) maintain some of the highest female graduation shares in the world (Tereshchenko et al., 2023). This high baseline is often attributed to the region's post-socialist legacy, which historically emphasized gender-neutral access to technical education as a component of state-led industrialization (Ferati et al., 2023; Reka & Memeti, 2024).

Educational Benchmarking: Bulgaria and Croatia

The trend remains robust across the broader Balkan landscape. In Bulgaria, women accounted for 31.5% of STEM graduates in 2023, a figure that remains stable and competitive with the EU (Guthrie et al., 2022). Similarly, in Croatia, female participation in ICT and engineering has benefited from early exposure to technical curricula, yet both countries exhibit the same "leaky pipeline" seen in North Macedonia. In Bulgaria, while the share of women in ICT is among the highest in the EU, they are significantly more likely to occupy entry-level or service-oriented roles (46%) rather than high-value manufacturing or R&D positions (22%) ("Eurostat," 2012; Travers et al., 2024). This suggests that the regional barrier is not a lack of interest or academic ability, but a structural "chilly climate" that redirects women toward less technical or lower-status sub-sectors (Ferati et al., 2023; González-Pérez et al., 2022).

Labor Market Disparities and the "Glass Ceiling"

The translation of education to employment reveals a sharp regional divergence. Across the EU, women represent 40.5% of scientists and engineers, yet in the Western Balkans, their presence in private-sector technological leadership is markedly lower ("Eurostat," 2012). In North Macedonia, the disparity is stark: despite high graduation rates, 70% of women in STEM eventually exit the sector (Reka & Memeti, 2024). This attrition is driven by a regional cultural climate where technical competence is still perceived as a masculine trait. Research across the Western Balkans indicates that only 12% of men view their female colleagues' computer skills positively, creating a pervasive "identity dissonance" for women in these fields (Ferati et al., 2023; Leka et al., 2024). This perception gap is a shared regional challenge that transcends national borders, affecting career commitment in Serbia and Croatia as much as in North Macedonia (Dost, 2024; Ferati et al., 2023).

Divergent Policy Responses: Serbia as a Regional Benchmark

While the challenges are shared, the policy responses in Southeast Europe are beginning to diverge, providing a roadmap for North Macedonia. Serbia has emerged as a regional leader by moving beyond "gender-neutral" language to implement "hard" policy instruments. The Serbian National Strategy for Gender Equality (2021–2030) has begun mandating Gender Equality Plans as a requirement for the accreditation of higher education institutions (Reka & Memeti, 2024). This contrasts sharply with North Macedonia's Education Strategy 2018–2025, which remains "gender-neutral" and lacks the specific "apparatuses and instruments" to address the 70% workforce exit rate (Reka & Memeti, 2024).

Furthermore, while Bulgaria has focused on strengthening mathematics programs to maintain its high graduation rates, it still lacks the binding quotas for corporate boards that are currently being proposed in North Macedonia to break the "glass ceiling" (Guthrie et al., 2022; Gjorgjioska et al., 2025). By comparing these national trajectories, it becomes clear that "access to education" is no longer the primary hurdle; the next stage of regional development requires institutionalized accountability—such as Gender Responsive Budgeting and mandatory bias training—to ensure that the region's high female technical talent is not lost to systemic attrition (Reka & Memeti, 2024; Vilhena & Pizarro, 2021).

Table 1: Key Comparative Data Summary

Country	Female STEM Graduates (%)	EU Comparison (32.2%)	Key Policy Status
North Macedonia	44.5% - 47.8% (Tereshchenko et al., 2023)	Significant Lead	High attrition (70%); lacks GEPs (Reka & Memeti, 2024)
Serbia	43.5% (Tereshchenko et al., 2023)	Significant Lead	Implementing mandatory GEPs (Reka & Memeti, 2024)
Bulgaria	31.5% (Guthrie et al., 2022)	Parity	High ICT participation; sectoral segregation ("Eurostat," 2012)
Croatia	~31-33% (Tereshchenko et al., 2023)	Parity	Strong early socialization; high "glass ceiling" (Cotter et al., 2001)

Policy Approaches and Gender Mainstreaming

Addressing gender inequality in STEM requires a strategic shift from formal equality (legal protections on paper) to substantive equality, which focuses on the actual career outcomes of women (Vilhena & Pizarro, 2021). While the Western Balkans region has made significant strides in closing the gender gap in education, the transition to the labor market remains the primary point of failure. This is particularly evident in North Macedonia, where a female STEM graduation rate of 47.8% (Tereshchenko et al., 2023) coexists with an attrition rate where 70% of women eventually exit the sector due to systemic prejudice and the unequal distribution of family care responsibilities (Reka & Memeti, 2024).

Addressing Institutional Gaps in North Macedonia

The current Education Strategy for 2018–2025 in North Macedonia identifies the need for gender equality but fundamentally lacks the "policies, apparatuses, and instruments" required for implementation (Reka & Memeti, 2024). For instance, while the strategy suggests revising textbooks to remove stereotypes, it fails to set measurable, sex-disaggregated goals for STEM enrollment (Reka & Memeti, 2024). Furthermore, existing labor market initiatives—such as the IT training courses launched by the Employment Agency Service—remain "gender-neutral" in their design. This neutrality is a policy failure, as it ignores the distinct socioeconomic barriers (e.g., lack of childcare or "identity dissonance" in male-coded spaces) that prevent women from accessing these opportunities (Dost, 2024; Reka & Memeti, 2024).

To bridge this gap, North Macedonia should look to regional benchmarks like Serbia, which has begun integrating mandatory Gender Equality Plans into the accreditation standards for higher education institutions (Reka & Memeti, 2024). Without such "hard" policy instruments, gender mainstreaming remains a rhetorical exercise rather than a structural reform.

Gender Responsive Budgeting and Economic Levers

A critical mechanism for translating these goals into reality is Gender Responsive Budgeting. Increasingly viewed in the Western Balkans as a bridge between social agendas and fiscal policy, GRB ensures that the distribution of public funds actively corrects resource imbalances (Reka & Memeti, 2024). For STEM, this involves:

- Targeted Social Support: Allocating budget lines for institutional support systems for student-mothers and caregivers (Reka & Memeti, 2024).
- Incentivizing Inclusive Hiring: Using fiscal policy to encourage affirmative hiring practices. Research indicates that when candidates are equally qualified, preferential selection of women helps correct for existing "lack of fit" biases without sacrificing technical competence (Bairoh, 2023).
- Binding Quotas: Moving beyond voluntary targets, there is a growing case for binding quotas on Macedonian corporate boards (Gjorgjioska et al., 2025). Such measures directly challenge the "glass ceiling" by ensuring that the 47.8% female graduate pool has a clear, institutionalized path to senior leadership (Cotter et al., 2001; Tereshchenko et al., 2023).

Curricular and Cultural Transformation

Finally, policy must address the "chilly climate" that begins in early socialization. Educational institutions must move beyond passive "encouragement" to active curricular reinforcement (Reka & Memeti, 2024). This includes:

- Mandatory Teacher Training: Training educators to identify and neutralize gender bias in subjects like mathematics and physics, where stereotypes often discourage high-performing girls (Cvencek et al., 2011; Ferati et al., 2023).
- Textbook and Media Reform: Mandating the visibility of female scientists in all state-approved educational materials to provide the role models necessary for long-term career persistence (Hamel, 2021; Reka & Memeti, 2024).
- Increasing Visibility: As only 12% of men in the region currently view their female colleagues' computer skills positively, policies must prioritize the public visibility of female technical contributions to challenge the cultural association between STEM and masculinity (Ferati et al., 2023).

In conclusion, effective gender mainstreaming in North Macedonia requires a move away from "gender-neutral" policies toward a Gender Responsive Budgeting framework that addresses the specific structural leaks—from enrollment to leadership—within the STEM pipeline (Reka & Memeti, 2024; Vilhena & Pizarro, 2021). This approach necessitates comprehensive data collection and analysis, disaggregated by sex and other relevant factors, to accurately identify disparities and measure the impact of interventions (Reka & Memeti, 2024). Such data standardization,

accompanied by proactive policy initiatives like scholarship programs, is crucial for fostering an environment conducive to women's advancement in STEM fields (Reka & Memeti, 2024).

Discussion

The findings of this study demonstrate that gender inequality in North Macedonia's STEM sector is a systemic phenomenon produced by the interaction of socialization, institutional norms, and labor market structures. While the region displays a high female share of STEM tertiary graduates—reaching 47.8% in North Macedonia, one of the highest globally—this educational success does not translate into labor market parity (Tereshchenko et al., 2023). This discrepancy confirms that "formal equality" in access to education is insufficient to ensure "substantive equality" in career outcomes (Vilhena & Pizarro, 2021).

1. The "Leaky Pipeline" and Feminist Institutionalism

From a feminist institutionalist perspective, the transition from education to the workforce represents a significant point of attrition. The "leaky pipeline" in North Macedonia is not a matter of individual choice but is driven by gendered institutional arrangements (van Anders, 2004). Despite graduating in high numbers, nearly 70% of women in STEM eventually drop out due to systemic factors, including workplace prejudice and the unequal distribution of family care responsibilities (Reka & Memeti, 2024). These findings support the argument that institutions continue to reward a "masculine career model" that relies on extreme presenteeism, effectively creating a "glass ceiling" that limits women's advancement to leadership (Cotter et al., 2001; Utzeri, 2019).

2. Social Identity and the "Lack of Fit" Paradox

The analysis reveals a stark disconnect between objective academic ability and professional belonging. While quantitative data shows that girls in North Macedonia frequently achieve better grades in mathematics than their male peers, they are still steered away from technical specializations (Ferati et al., 2023). Social identity theory helps explain this paradox: even high-achieving women may opt out of STEM if they perceive a "lack of identity fit" within a culturally coded masculine environment (Cheryan et al., 2016; Master et al., 2015). This is evidenced by regional peer perception data, where only 12% of men viewed their female colleagues' computer skills positively, and men consistently gave lower ratings to female teachers

in technical courses (Ferati et al., 2023). Such a "chilly climate" discourages long-term persistence and reinforces the belief that technical competence is a masculine trait (González-Pérez et al., 2022; Leka et al., 2024).

3. Gender Role Socialization and Enrollment Disparities

The disparities begin well before the labor market, rooted in early gender socialization. In North Macedonia, only 15.69% of women enroll in STEM faculties compared to 25.72% of men (Reka & Memeti, 2024). This mirrors global patterns where math-gender stereotypes emerge as early as second grade, influencing self-concept before actual achievement differences exist (Cvencek et al., 2011). Even though 95% of women in the region view Computer Science as an "adequate" field for their gender, traditional family investments and social frameworks continue to funnel them toward "feminized" science-related majors (like teaching) rather than engineering or technology (Ferati et al., 2023; Özdemir & As, 2022).

4. Policy Limitations and the Path Forward

Finally, this study highlights the limitations of current policy approaches in North Macedonia. The Education Strategy 2018–2025 sets broad goals for women in STEM but lacks the specific "policies, apparatuses, and instruments" needed for implementation, such as mandatory teacher training on gender bias or specific textbook reforms to provide equal visibility to female scientists (Reka & Memeti, 2024). To bridge this gap, the findings suggest that regional interventions must move beyond "increasing participation" and toward Gender Responsive Budgeting and institutional reforms that address the "masculine culture" of ICT sectors directly (Gjorgjioska et al., 2025; Reka & Memeti, 2024).

Overall, addressing these inequalities requires a shift from viewing STEM disparities as an "individual choice" problem to recognizing them as an institutional regime that must be transformed through coordinated structural change (Baguant et al., 2023; Vilhena & Pizarro, 2021).

"This study significantly advances the scholarship on STEM gender gaps by offering a holistic analytical framework that integrates gender role theory, social identity theory, and feminist institutionalism—perspectives often examined in isolation (Anglin et al., 2022; Vilhena & Pizarro, 2021). By applying this framework to the understudied context of Southeast Europe, the analysis moves beyond descriptive accounts of the 'leaky pipeline' to explain the specific institutional mechanisms that sustain the regional paradox: where high educational attainment (e.g., 47.8% in North Macedonia) fails to translate into professional parity (van Anders, 2004;

Ferati et al., 2023; Tereshchenko et al., 2023). Ultimately, by linking these theoretical insights to concrete policy gaps in regional strategies, this paper provides a robust framework for designing multi-level interventions that address both early socialization and the structural 'glass ceilings' within the ICT and engineering sectors (Cotter et al., 2001; Reka & Memeti, 2024)."

Conclusion

Gender inequality in STEM remains a systemic challenge shaped by the tension between high educational attainment and restrictive institutional cultures. This study has highlighted a significant regional paradox: while North Macedonia achieves a female STEM graduation rate of 47.8%—one of the highest in the region—women remain disproportionately likely to divert into teaching careers or exit the technology sector entirely (Ferati et al., 2023; Tereshchenko et al., 2023). This "leaky pipeline" is not merely a result of personal choice but is driven by a "chilly climate" where only 12% of men in the region view their female colleagues' computer skills positively, reinforcing the notion that technical competence is a masculine trait (Baguant et al., 2023; Ferati et al., 2023).

Achieving substantive equality requires moving beyond formal policy commitments to address specific structural gaps. A critical priority for North Macedonia is the implementation of sex-disaggregated data collection by field, the absence of which currently "complicates the assessment of women's status" and prevents targeted interventions (Reka & Memeti, 2024). Furthermore, educational reforms must prioritize early exposure to computer science and coding in primary curricula to build self-assurance before gendered "identity dissonance" takes root (Cvencek et al., 2011; Leka et al., 2024).

Ultimately, expanding women's participation in STEM is a strategic necessity for regional economic development. As current disparities in job selection exacerbate economic vulnerability and unequal earnings, empowering women in technical fields is essential for fostering a prosperous and inclusive society (Gjorgjioska et al., 2025; Reka & Memeti, 2024). By transforming the institutional rules that sustain the "masculine career model," North Macedonia can ensure that its high educational success leads to measurable leadership outcomes (van Anders, 2004; Utzeri, 2019).

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