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WOMEN IN STEM - CHALLENGES AND OPPORTUNITIES

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Abstract

The pursuit of doctoral studies in Science, Technology, Engineering and Mathematics (STEM) represents a significant pathway for young women to advance their careers, foster personal development and contribute to diverse fields of scientific and technological innovation. Young women must stay motivated and involved in the various fields of technological development, informatics, science and mathematics. Today we can see how that traditional barrier of divisions of male or female fields of science is breaking down. The opportunities for women's advancement are at a high level and they can contribute with their talent to making different types of decisions or running their own businesses. This paper focus on identifying and promoting initiatives aimed at motivating young women to pursue higher education in STEM disciplines. A key aspect of this research involved analyzing the educational trajectories of female students in our region, particularly focusing on enrollment, retention and completion rates at both undergraduate and doctoral levels. Through our analysis, we observed that, while more women are entering STEM fields, there remains a significant underrepresentation in doctoral programs within the Pelagonian region. This suggests that, despite growing interest, there are persistent barriers preventing women from pursuing and completing doctoral studies in STEM. Our methodology includes exploring motivational factors and institutional support mechanisms that could better encourage young women to continue their education in STEM. We research which targeted initiatives and support systems should be implemented in order to empower more women to achieve advanced qualifications, thereby enhancing diversity in STEM leadership and contributing to broader societal and technological advancements.

Keywords: women; inclusion; STEM; innovation; challenges; education.

INTRODUCTION

The term Women in STEM generally refers to the representation and participation of women in the fields of science, technology, engineering, and mathematics (Jiang 2021). Numerous studies and industry analyses focus on evaluating the proportion of female employees in these sectors and examining gender balance within the workforce. In this study, we chose to shift the focus towards investigating perceptions related to the education and presence of women in these disciplines, exploring the underlying factors influencing their participation and progress (Blackburn 2017, 235-273). Education brings transformative changes that make the country stronger. Investing in the educational process itself means a challenge. Career advancement is based on how much an individual invests in their personal development. We have witnessed that the path to achieving the goals set is not always simple, it is a thorny pair intertwined with a series of obstacles and difficulties that build the person to be filled with greater experience and greater inclusiveness in decision-making. The growing demand for a skilled workforce and the rapid development of industry have necessitated the inclusion of women in various professional sectors, prompting a shift away from their traditional roles as mothers and housewives. The decision to take a step and continue studying for doctoral studies especially in the field of science, mathematics and informatics is a challenge for women (Johnonson et al. 2000, 135-147).

An increasing number of young women are opting to pursue studies in STEM-related fields; however, the question remains: how many successfully complete their education in these disciplines?

This paper presents an analysis of various criteria related to the enrollment patterns of male and female students in STEM faculties within the Pelagonian region. The study examines the percentage of students who graduate and pursue further education, including master's and doctoral programs, providing insights into trends and disparities in higher education progression. Additionally, the paper identifies and explores the challenges faced by women in STEM, offering a deeper understanding of the barriers that may impact their participation and success in these fields (Kanalic et al. 2013, 86-90). Diversity adoption and inclusion initiatives play a crucial role in encouraging women to pursue advanced degrees in science, mathematics, and informatics. These initiatives create an environment that values diverse perspectives, fosters a sense of belonging, and provides the necessary resources and mentorship to navigate the challenges of studies (Shein 2024),(Carter et al. 2012).

WOMEN FROM PELAGONIAN REGION IN HIGHER EDUCATION

The involvement of women in higher education has become a significant focus of research and policy, particularly in regions such as Pelagonian, where economic, cultural and social factors influence educational opportunities. Understanding the participation of women in higher education within this region provides insights into gender equity, access to educational resources and societal progress. Analyzing enrollment data across undergraduate, master's, and doctoral levels reveals patterns in women's choices of academic disciplines, with particular emphasis on their representation in STEM fields (White 2024).

OVERVIEW OF THE RESEARCH METHODOLOGY

This research methodology was structured around three main focal phases. The first phase involved identifying faculties within the Pelagonian region to serve as the basis for investigating the representation of women in STEM. Following this initial analysis, we

selected two faculties from the University "St. Kliment Ohridski" in Bitola: the Faculty of Information and Communication Technologies and the Faculty of Technical Engineering. These institutions were chosen to provide a comprehensive perspective on the presence of women in STEM-related fields within the region. The second phase involved defining the criteria for analysis. This phase concentrated on evaluating data pertaining to undergraduate graduates, master's degree students categorized by the scientific fields of their theses, and doctoral students classified according to the disciplines of their dissertations. The third phase focused on analyzing the results and drawing conclusions. This stage identified key challenges contributing to lower graduation and enrollment rates among women in STEM fields. Furthermore, it highlighted targeted initiatives and support systems that could be implemented within the Pelagonian region to enhance the participation and success of women in STEM disciplines.

Throughout the research phases, we encountered a wealth of information and insights into the needs and challenges faced by female students. Based on the newly identified information, opportunities, and conclusions, we developed a prototype model for institutional support mechanisms aimed at raising awareness and fostering greater participation of women in STEM education.

COMPARATIVE ANALYSIS OF DATA

A timeline analysis of data from both faculties was conducted covering the period from 2020 to 2023, inclusive of the entire year of 2023.The data utilized for this research was sourced from publicly accessible online datasets provided by the State Statistical Office of the Republic of North Macedonia (State Statistical Office of Republic of North Macedonia 2024), as well as from faculty student affairs offices for the first, second, and third cycles of study.

Over the past four years, the number of male graduates has consistently surpassed that of female graduates at both faculties, as shown on below Fig.1.

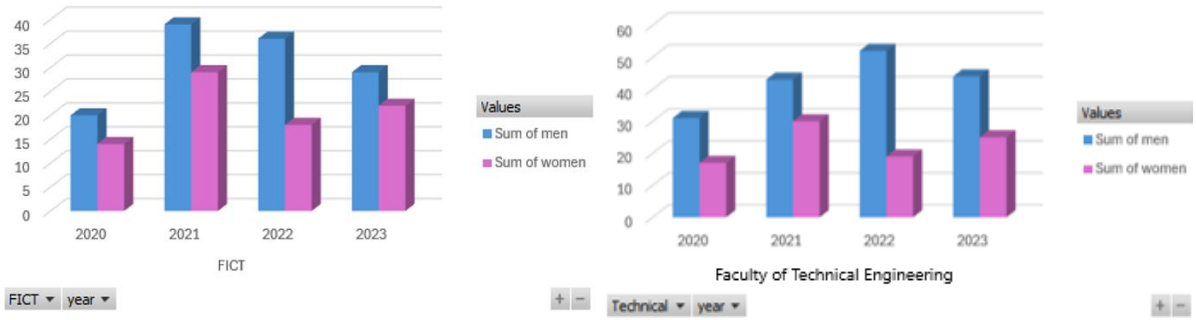

Fig 1. Visualization of Graduated students in the last four years (Source: Own depiction)

The distribution of graduates over the past four years, categorized by type of study, reveals significant patterns in the academic progression of students at both faculties.

To further examine differences in student graduated status, specifically between full-time and part-time students, and to assess the distribution over the past four years, we conducted a comprehensive breakdown and visualization of the data. The analysis revealed that, in both faculties, the majority of full-time students were male, Fig.2.

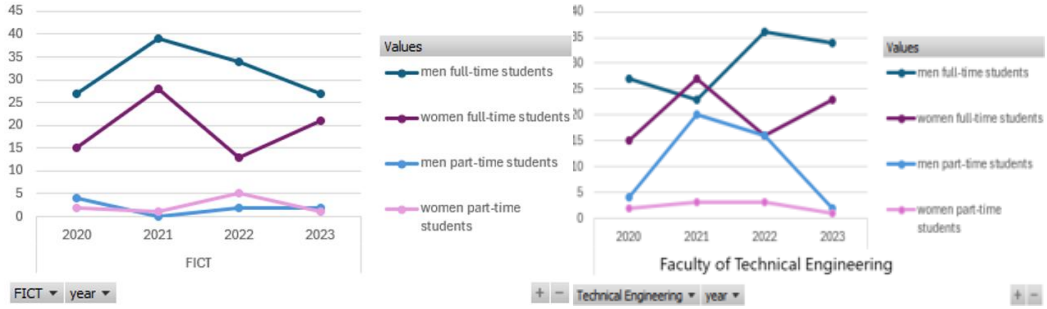

Fig. 2. Students graduated in the last four years, by type of studying (Source: Own depiction)

This analysis considers the various levels of academic attainment, including undergraduate, master's, and doctoral degrees, offering insights into the trends and shifts in student enrollment and graduation rates. In the first-cycle studies at the Faculty of Information and Communication Technologies, for two academic years, the enrollment rate for women has decreased in comparison to that of men. Our analysis reveals that the number of female graduates is consistently lower than that of male graduates, indicating a gender disparity in both enrollment and completion rates, Fig.3.

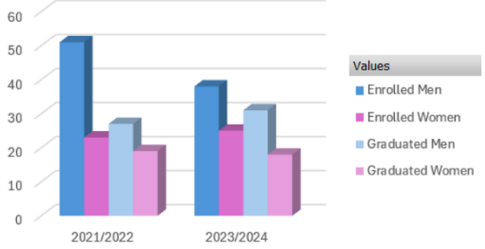

Fig. 3. First cycle analysis for the Faculty of Information and Communication Technology (Source: Own depiction)

The total number of Master of Science, categorized by the scientific fields of their theses, reveal that the proportion of female graduates has consistently remained lower than that of their male counterparts over the years, Fig.4.

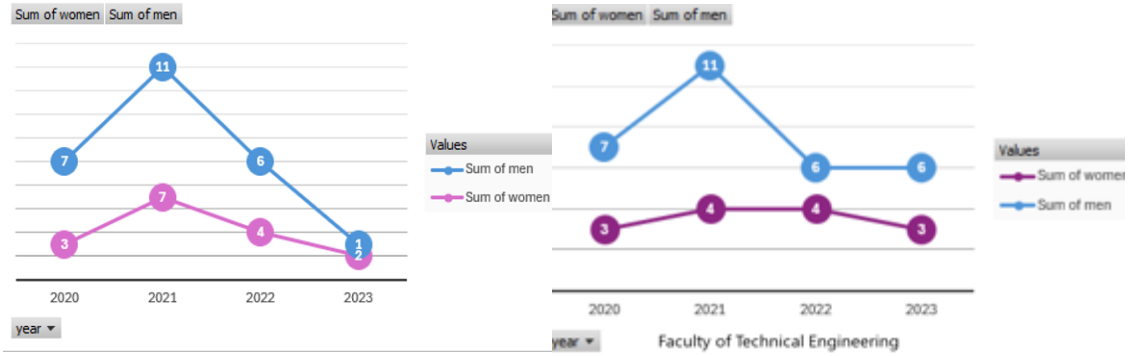

Fig 4.Total numbers of Master of Science according to the scientific field of the master's thesis (Source: Own depiction)

According to the scientific field of the doctoral dissertation we had analyzed the data from the Faculties in North Macedonia, specifically in:

- Natural Sciences, Mathematics and Statistics
- Information and Communication Technologies (ICT)
- Engineering, Manufacturing and Construction.

In 2020 and 2021, the number of female PhD graduates exceeded that of their male counterparts. However, by 2022 and 2023, there was a significant increase in the number of

male students completing doctoral programs in these fields, highlighting a shift in gender representation at the doctoral level, Fig.5.

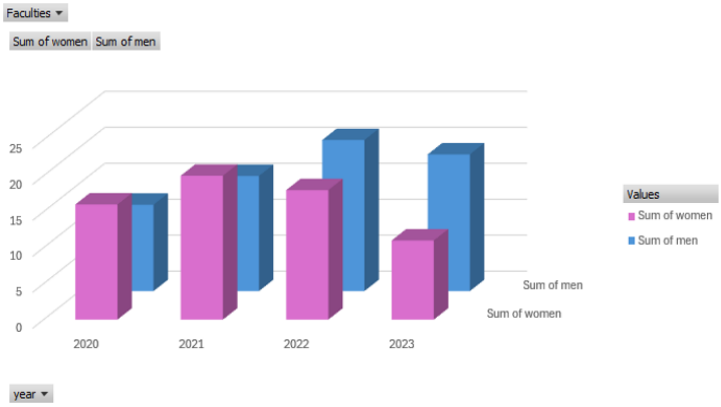

Fig. 5. Doctors of science according to the scientific field of the doctoral dissertation (Source: Own depiction)

By examining the data across these categories, we can better understand the academic trajectories of both male and female students, as well as the influence of different fields of study on overall graduation outcomes.

CHALLENGES DETECTED

In today's world of rapidly developing technologies and new opportunities for innovation, women's resilience and adaptability are more important than ever. The educational landscape is continually evolving with new programs, branches of learning, and fields of research emerging. This dynamic cycle demands that women not only keep pace but also lead the way, using their unique perspectives and talents to drive progress and foster inclusivity in every sphere (Neneh 2021). Through our research were identified a range of internal and external factors that significantly affect women's decisions regarding the continuation of their education. The following challenges are leading to the lower graduation and enrollment rates for women:

- **Financial barriers:** economic limitations may affect families' ability to support higher education, sometimes prioritizing education for men due to cultural or economic factors (STEM Women 2024).
- **Work-Life balance challenges:** balancing educational pursuits with family or caregiving responsibilities can pose significant challenges, often disproportionately affecting women (Brue 2019).
- **Gender stereotyping in education:** stereotypes about specific disciplines being more suited for men can discourage women from enrolling in those areas (Flores 2018, 291-345), (Bauer 2020).
- **Lack of encouragement and support:** without support from family members, women may feel isolated or discouraged, affecting both enrollment and completion rates (Glass et al. 2010, 218-229).
- **Self-Sacrifice for family needs:** women are often socialized to be self-sacrificing, which may lead them to put family needs ahead of personal goals (Kann et al. 2017).
- **Marriage and early family commitments:** in some families, there is pressure for women to marry early or prioritize family life over personal educational goals (STEM Women 2024).

TARGETED INITIATIVES AND SUPPORT SYSTEMS

The challenges faced by women pursuing higher education in technology are multifaceted and require coordinated efforts to address. Educational institutions, industry leaders, and policymakers must work together to create supportive environments, provide mentorship and financial resources, and actively combat gender biases (Handley 2024). By recognizing and addressing these challenges, we can pave the way for more women to succeed in technology, ultimately driving innovation and diversity in the field. Here are a few initiatives that can be implemented in our region:

- **Scholarship programs for women in STEM** – offering a scholarship specifically for female students in STEM fields, to encourage enrollment and alleviate financial burdens.
- **Career awareness and counseling** - more workshops, counseling sessions, and career days to highlight career paths and opportunities for women across various fields, helping them make informed decisions (Robnett 2016, 65-79).
- **Dedicated women's resource centers** - centers that provide academic, emotional, and financial support tailored to the unique needs of female students
- **Flexible study options in part-time programs** - introducing part-time programs, evening classes or online options to accommodate students with other responsibilities, such as family obligations, allowing them to continue their studies without sacrificing their personal life (Tuijl et al. 2015).
- **Alumni and industry engagement** - collaboration with alumni and industry leaders to create initiatives aimed at increasing female participation in higher education and bridging the gender gap in the workforce.

By implementing these strategies, can be created a more supportive and equitable environment that encourages more women to enroll, persist, and succeed in higher education specifically in STEM fields.

INSTITUCIONAL SUPPORT MECHANISMS MODEL

Over all opportunities that can encourage young women to continue their high education, we build a prototype institutional support mechanism model that will empower women in STEM fields through a structured approach that includes five key stages: planning, marketing, design, strategy, and launch . Each stage addresses specific objectives and opportunities aimed at increasing female participation and success in STEM disciplines, Fig.6.

Planning	Marketing	Design	Strategy	Launch
Who should be included? What we want to accomplish? How we can do that ?	Determinate a target group (starting from high schools' programs) and students from first cycle studies.	Continues cycle process Inclusion on the women and networking strategies	Focus on superior methodologies Work-Life balance for women Create Monitoring and Evaluation Framework	Engage Community and Industry Stakeholders Raise Awareness and Challenge Stereotypes

Fig. 6. Institutional support mechanisms model (Source: Own depiction)

This initial stage **planning** - focuses on defining the goals and determining the strategies necessary to achieve the objectives. Opportunities at this stage are establishing a clear roadmap for the initiatives targeting women in STEM and fostering collaboration between academia, industry and community organizations.

The **marketing** phase emphasizes outreach and engagement by determining the target audience, such as students from high school programs and first-cycle university students. Effective communication strategies ensure that the message reaches the intended demographic**.** As opportunities at this level are raising awareness among young women about STEM career and encouraging early interest in STEM fields through specific programs and mentorship.

Third level, **design** phase ensures the development of a continuous and inclusive process that integrates women into the STEM ecosystem. Networking strategies are also emphasized to foster connections and support systems. Opportunities at this phase are building sustainable systems that encourage long-term engagement of women in STEM and creating networking opportunities to connect female students with role models.

The **strategy** phase focuses on implementing methodologies and frameworks to address specific challenges. It includes:

- Emphasizing work-life balance for women.
- Developing a monitoring and evaluation framework to assess progress

As opportunities are introducing superior pedagogical and support methodologies to enhance learning experiences and ensuring gender-sensitive policies that support work-life balance, enabling more women to thrive in STEM careers.

The last phase is **launch**, which brings the model to life by engaging communities, industry stakeholders, and other partners. It also aims to raise awareness and challenge stereotypes that may discourage women from entering STEM fields. With implementation of this phase the opportunity will be mobilizing community and industry resources to support women in STEM.

This model provides a structured, actionable framework that can be adapted by institutions in our region to support women in STEM fields effectively and sustainably.

CONCLUSION

Education has proven to be a powerful instrument for shaping gender relations and driving social change. It is vital in molding the views of children and young people, providing new opportunities for constructing gender identities and promoting gender equality. In this paper, we explore the key components that influence the path to enrollment at high education and emphasize the critical importance of encouraging and supporting women's participation in these programs, specifically in the Pelagonian region. Women's involvement in STEM studies is not only beneficial for their personal and professional growth but is also essential for fostering innovation, promoting gender equality, and driving social progress. By supporting and encouraging more women to pursue doctoral degrees, we can create a more inclusive and dynamic academic environment, ultimately leading to a better and more equitable region. Our support mechanism model focuses on encouraging young women to study on STEM fields and continuing their education.

This paper examines the factors influencing women's interest in STEM and all the new opportunities during the studying journey. Additionally giving support to all women involved in doctoral studies and in same time encouraging other young women`s to continue the academic process for many more career successes and further leadership positions.

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