Navigating the Personal and Professional: How University STEM Mentorship Programs Support Women in Austria and Germany

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Introduction

The underrepresentation of women in Science, Technology, Engineering, and Mathematics (STEM) fields isn't just a statistic – nor a debate – it's a persistent global issue [1]. Although significant progress has been shown to promote gender equality in society, women holding positions in the higher echelons of predominantly male-centric STEM fields remain a rare phenomenon [2]. Recent statistics support these findings, shedding light on the stark reality of such disparities, revealing that the global representation of female STEM students stands at a mere 35%, plummeting to 28% for doctoral students [3]. In regions such as South Asia, Sub-Saharan Africa, and West Asia, one in five researchers in STEM are women [3].

According to Werz, Schmitt, Borowski, Wilkesmann, & Isenhardt [4], relatively few women decide to pursue STEM degrees in higher education, and even fewer enter the workforce in these fields, of which a tiny fraction manage to attain that middle or higher management status positions. For example, in the Netherlands, approximately 24% of STEM graduates are women, of which 71% opt for a career outside STEM; as a result, only 13% of STEM workers are women – putting the Netherlands at the bottom of European rankings in the share of women in STEM [5],[6]. At the university level in German institutions, women constitute less than one-fifth of STEM majors, with alarming figures as low as 11% in electrical engineering, 19.9% in computer science, and 17.2% in mechanical and process engineering [7].

Global efforts to address this imbalance and close these gaps in STEM performance representation and engagement have become an issue of international importance [9]. STEM mentorship programs have emerged as a powerful resource and tool for empowering and supporting women in pursuing STEM careers [8]. Mentorship programs encompassing initiatives, policies, and networking opportunities have gained significant momentum worldwide [3],[10].

Studies show a direct correlation between effective mentorship programs leading to increased access, participation, and representation of women in STEM fields and careers [9],[10]. Researchers attest that investing in mentorship programs is not simply about closing the gender gap. Still, it is more about unlocking the full potential of our collective human talent [9]. Research indicates that substantial research has focused on STEM graduate mentorship programs [9],[10], effectiveness measures [9],[11], and the impact on mentees' career trajectories [9]. However, more research is needed to examine the effectiveness and generalizability of STEM graduate mentorship program implementations [9].

Moreover, research suggests a lack of research evaluating STEM mentorship programs in educational settings for women in Germany [12] and Austria [13]. With the growing interest in STEM mentoring, it is crucial to fill this knowledge gap and understand what constitutes effective practices on a global scale, particularly within higher education and

international outreach contexts such as Austria and Germany. Given the growing interest in female STEM mentoring, a gap exists in our understanding of what constitutes effective practices on a global platform – especially in higher education and global outreach contexts. Furthermore, while the last decade has seen significant advancements in identifying effective practices for general youth mentoring programs, direct research on the specific nuances and strategies that make STEM mentoring most effective is still lacking. A major review of relationship-based STEM interventions highlighted the scarcity of research in this area, emphasizing the need to set an objective aiming to examine the best practices and lessons learned for building impactful women-focused STEM mentorship programs for global reach.

Purpose

The present study aims to gain a more profound understanding of practical and evidence-based insights into women-focused STEM mentorship initiatives, specifically to better understand the efficacy of mentoring programs aimed at supporting women in STEM, particularly those at the graduate and early career stages in academia – which includes students stemming at the bachelors, graduate and doctoral level. The following overarching research question guided the development of this research study: What are the key factors that contribute to the effectiveness of university STEM mentorship programs in promoting the advancement and success of women in engineering and technology fields within the specific contexts of Austria and Germany? Furthermore, the following open-ended interview questions were used to capture more nuanced insights:

1. What aspects of STEM mentoring programs are most effective in supporting women in STEM toward their academic and career goals?
2. What types of leadership, institutional, and peer support are necessary to ensure that a mentoring program for women in STEM is effective?
3. What factors or supports could help to improve the effectiveness of existing mentoring programs for women in STEM?

By conducting in-depth qualitative case study interviews within select Austrian and German university mentorship programs – educational spaces chosen due to their similarities in higher education structures, gender equity policies, and gender representation within STEM fields – we seek to capture program design, effectiveness, challenges, and successful strategies. Additionally, as researchers from one of the world's largest advocates for change for women in engineering and technology – our goal is to identify what nuanced themes and patterns, lessons learned, best practices, and evidence-based recommendations exist to potentially lessen the gender disparities in mentoring and STEM on a global scale.

Literature Review

Leaky Pipeline

Despite numerous efforts to improve the representation of women in STEM fields, an increased undergraduate enrollment across these disciplines has not translated to gender parity at later

career stages – creating a funneling effect most commonly referred to as the leaky pipeline. First coined by Margolis and Fisher (2002), the metaphor brings attention to specific issues affecting efforts to reach gender parity in STEM, including (i) a lack of female role models via visible female leaders to serve as inspiration and encouragement; (ii) ingrained societal stereotypes via biases and preconceived notions that discourage women and girls from pursuing careers in STEM; and (iii) the struggle for work-life balance via classroom dynamics such as learning spaces and curriculum design and methods that inadvertently create barriers [14].

These factors simultaneously continue to funnel and shrink women's opportunities as they traverse through their STEM education and into the workforce, thus declining women's interest in remaining in STEM. The leaky pipeline theory entails that the "progressive loss of competent women in STEM has been identified at various career stages, including the bachelor's-to-PhD pipeline [15], the academic employment stages of selection [16], promotion [17], and retention [18]. The pipeline not only poses a significant threat to the overall value of STEM degrees but also perpetuates this pervasive metaphor to "erode away social and cultural forces that keep talented individuals from "making it –people tend to "leak out" at the bachelor's or master's degree levels as they leave school to go find a job or change their career paths altogether [19]."

Obstacles and Challenges

Researchers linking STEM fields with masculinity have discovered a profound and lasting negative influence on girls and women [20]. Studies indicate biases negatively influence young girls' self-perception and educational choices, a decreased belief in their ability to excel in STEM disciplines – ultimately dissuading them from pursuing careers in these fields [21], [22]. Furthermore, previous research indicates that economic and societal implications significantly contribute to gender pay gaps, curtail economic progress, and impede overall societal development [22],[23]. For example, the World Economic Forum (2018) estimates that closing the gender gap in STEM would potentially add trillions of dollars to the global GDP over the next decade, emphasizing the economic significance of gender disparity in these fields.

Moreover, research shows that cultural and societal expectations, particularly those related to childbearing and household responsibilities, also contribute to the underrepresentation of women in STEM [24]. These expectations can further deter women from pursuing and advancing in STEM careers [24] and limit female mentees' opportunities for networking and professional growth [25]. Implicit biases in hiring and promotion practices within STEM fields have also been documented by several scholars [26],[27] – finding disparities in their representation and advancement significantly impact the trajectory of women's STEM careers. Additionally, gender-based discrimination, harassment, and hostile work environments remain pervasive issues within STEM fields that contribute to lower retention rates and gender inequalities within the STEM scientific community [28],[29].

Mentors and Protégés

In the evolving world of STEM, a STEM mentor emerges as a guiding role model supporting the generations of scientists, engineers, and mathematicians [30]. Aside from being a career advisor, a STEM mentor plays a pivotal role – sharing not only their knowledge and expertise within their respective fields but also equipping mentees (i.e., referred to as protégés within the global context) with resources and introducing them to the conduct, culture, and traditions of the given field [31],[32],[33]. Mentoring has long been recognized as a tool for attracting and retaining women in STEM careers and serving as a resource for emotional and psychosocial support to potentially mitigate feelings of isolation [34]. For many protégés, mentors offer networking opportunities and provide ongoing support to boost confidence and personal growth [35]. Research indicates that women-focused mentorship programs play a positive role in helping break down barriers, reduce stereotypes, and help reduce dropout rates among first-year female students pursuing STEM [36].

Beyond College

Extensive research shows that women-focused STEM mentorship programs offer the landscape to make connections and navigate the challenging spaces of STEM careers [37], [38]. Scholars indicate workshops' critical and transformative role in combating imposter syndrome, a common challenge that undermines self-confidence and career progression. Research shows that workshops that focus on the leadership development aspect for women in STEM and target specific STEM-related training ranging from boot camps to data analysis to career guidance – equip women with the necessary skills to access and excel in leadership positions [39].

Furthermore, research shows that women-focused STEM mentorship programs increased soft skills, such as negotiation, communication, and conflict resolution, which are vital for navigating gender-biased workplace dynamics. Additional research sheds light on the mentorship programs' role in helping women in STEM fields, especially in a predominantly male-dominated field – revealing opportunities to build social capital, the impact of mentorship programs pairing women via increased visibility and career advancement, practical strategies for effective time management and prioritizing well-being and skills and training to equip women to combat challenges related to systemic biases and discrimination [9].

Methods

Drawing on practices and lessons learned from STEM mentorship programs at local, state, and national levels in the United States, our study utilized a qualitative case study approach informed by the expertise of academics involved in STEM mentorship programs at Universities in Austria and Germany.

All four participants were women. Informal interviews were conducted in English, eliminating any potential issues that could arise from language barriers during the transcription phase of this study. The interviewees were virtually interviewed via platform Zoom, and research questions were semi-structured with an open-ended format.

Given that this study involved human subjects, we obtained IRB approval. Nonetheless, the international dimension of the study introduced a layer of complexity – a comprehensive

review and integration of the relevant policies and bylaws from Austria and Germany. This preparatory work was essential to ensure adherence to both local and international codes of ethical standards prior to obtaining IRB approval.

Recruitment of case sites

This study builds on the Society of Women Engineers expansion and engagement efforts with STEM students and professionals in Europe. In May 2019, a member event took place in Berlin, Germany, providing an opportunity to connect with individuals involved with STEM mentoring programs at universities in Germany and Austria, a country whose higher education structure aligns with Germany's. Through recommendations from our organization's Research Advisory Council, individuals from various university STEM programs involved with mentoring activities were invited to attend a research roundtable discussion held in a conference room at a Berlin Technical University. The focus of the discussion was on gender diversity in STEM education, with the intention to build a research study from the outcomes of the discussion.

When reviewing the transcripts from the discussion, we found an emphasis on the effectiveness of mentoring programs for women in STEM. We wanted to develop a research study to learn more about what made these mentoring programs effective. However, COVID-19 delayed our efforts to conduct a study. In 2022, after many of the pandemic restrictions were lifted, we reconnected with those we spoke with in 2019 to move forward with this case study.

The selected case study sites were based on recommendations from the individuals who participated in follow-up research discussions held in July and November 2022. The individuals invited to these discussions included representatives from the United States, Germany, and Austria, many of whom worked with university STEM programs as educators and administrators. The outcomes from these discussions and additional research conducted based on recommendations from participants guided the selection of sites and shaped the study's direction, objective, and methodology.

Specifically, researchers emailed invitations to the directors of six mentoring programs that were recommended by those involved with our research discussions and asked them to participate in the case study. The goal was to study two programs in Germany and two programs in Austria. We approached six directors with the hope that at least four would agree to participate. However, only one individual in Austria agreed to participate while three from Germany agreed.

The four case sites selected for interviews are listed in Table 1. Program Case Sites and Table 2. Interviewee Background.

Table 1. Program Case Sites

Program	Location	Focus	Target Audience	Eligibility Requirements	Program Structure	Strengths (from Interviews)	Challenges (from Interviews)	Best Practices (from Interviews)
Program 1	University in Berlin, Germany	Encourage and support female doctoral students and postdocs in science careers	Female doctoral students and postdocs	Must be enrolled in a science PhD program or hold a science postdoctoral position	One-on-one mentoring, workshops on career development, networking events	Matching mentors with similar research interests	Retaining mentors who transition to new jobs	Ongoing mentor training, strong program community
Program 2	Subsidiary of a technical university in Munich, Germany	Support female students in academic and professional development	Female students	Enrolled in any program at the technical university	Peer mentoring, industry visits, professional skills development workshops	The success of Peer Mentoring in building a supportive Community	Attracting a diverse pool of female students	Regular program evaluation and adaptation
Program 3	Science University in Austria	Inspire and support young people, particularly women, in computer science, natural sciences, or technology	Young people, particularly women	High school students or early university students	Group mentoring, summer camps focused on STEM topics, guest speaker sessions from female leaders in STEM fields	Positive impact of project-based learning	Securing funding for long-term program activities	Creating a strong sense of community among participants
Program 4	University in Munich, Germany	Build digital, scientific, and entrepreneurial leadership skills for women with non-academic backgrounds	Women with non-academic backgrounds	There are no formal education requirements, but interest in STEM fields is preferred	Program with intensive workshops, mentorship from female entrepreneurs and digital leaders, project-based learning	Value of project-based learning for practical skill development	Ensuring all participants feel comfortable in the program	Emphasis on unconscious bias training for mentors

Table 2. Interviewee Background

Role	Description
Gender and Diversity Manager	Shapes and implements diversity in mentorship programs, contributing to inclusivity and effectiveness for women in STEM.
STEM Graduate Student (Mentor)	Provides insights for mentees pursuing academic paths based on their experience as a STEM graduate turned mentor.
Head of the STEM Mentoring Program	Leads, coordinates, and oversees the program, providing insights on structure, goals, impact, and challenges.
Non-STEM Project Manager	Contributes to diversity retention and performance despite lacking a STEM background. Offers different skill sets and perspectives to enrich the program.

Interview Design

Interviews were used to capture central themes that explore the efficacy of mentoring programs for women in STEM. A semi-structured interview protocol was developed in collaboration with McNamara's principles for interviews – utilizing guidelines and considerations to conduct effective, meaningful, and reliable interview-based research. The interview questions allowed the participants to describe the strengths and challenges associated with their women in STEM mentoring programs, including:

- Eligibility to participate in their STEM mentoring program.
- Current participation in their program;
- The leadership, institutional, and peer supports offered that help the program be effective;
- Best practices and areas for improvement;
- Challenges and successes encountered while mentoring within STEM; and
- Suggested strategies and initiatives for others considering developing a mentoring program for women in STEM.

Data Analysis

Data analysis techniques involved digitally recording conversations via the online platform Zoom. All recordings were transcribed. The thematic and qualitative analysis involved finding, coding, and analyzing recurring themes that originated from the interview transcripts while ensuring interreliability to ensure conversations were synthesized. Adhering to ethical research protocols, the researchers employed a multifaceted approach to ensure the transparency of the findings presented in this study. This included utilizing well-validated measures throughout the study to enhance reliability and conducting inter-rater reliability checks to guarantee consistency in data collection. To further strengthen the validity of their conclusions, the study incorporated triangulated data from multiple sources, including one-on-one interviews and a thorough review of relevant academic scholarly journals.

Results

The following four themes emerged from the data analyses and in-depth case study interviews. First, institutional support and leadership commitment via female STEM mentorship programs appear to be pivotal factors for the success of mentees enrolled in the program's various opportunities. Interestingly, one recurring theme that stemmed across case sites suggests that the potential for high-level support from mentors from various sectors in academia appears to be important in shaping the program’s overall effectiveness. For example, one participant emphasized that one of the many roles in creating a supportive and

personalized environment for mentorship is maintaining a safe and welcoming environment that promotes supportive and inclusive spaces:

> "Our program is based on a one-on-one mentoring... complemented by mentee cohort... personal relationship and then the mentee group... to discuss these kinds of questions are very important for our participants."

Similarly, another participant mentioned the importance of aligning the program with institutional goals and the culture that surrounds the mentorship spaces, such as workshops and training. These mentorship offerings are further supported on a systemic level that aims to create diverse and meaningful opportunities to connect with mentors and networking opportunities based on shared interests and goals.

> "We started with a bit [of] traditional mentoring, but we put [that aspect] away so that – we learn from each other, and it's also the goal we have to learn from each other."

Another theme that stemmed from the interviews was the need for mentorship programs to ensure that mentees understand the purposes of the mentoring program as well as what a mentorship program entails – so that they do not feel that they are lacking or unequipped to handle the rigors of a STEM education or career but rather feel supported, welcomed, and included:

> "Finding that fine line between, we are offering you this mentoring program, because we believe in you, and not because you're a victim, or you need guidance or support."

Second, our analysis of the case sites involved consistently showed that one strength included having a space that initiates a personalized and tailored mentorship experience – especially regarding mentor-mentee matching and goal setting, which emerged as a critical and guiding factor that reinforces the connections. Some participants acknowledged the value behind individualized mentor-mentee and the positive aspects of pairing mentors with mentees based on shared interests, professional fields, or career goals. As described in research and case studies, this personalized approach highlights each mentoring relationship and fosters more meaningful and effective engagements between mentors and mentees.

> "Regular get-togethers because we also find that... minorities are looking for their peer group, they're looking for others who they feel like they can identify with and connect with."

Third, the significance of ongoing program evolution and adaptation was consistently observed. Starting simple and adapting based on participant feedback and changing needs ensures that the program remains relevant and effective. As one participant noted the importance of adapting mentorship programs to address specific group needs, such as first-generation students and diverse gender identities – strengthens inclusivity and representation in STEM fields.

> “We want to connect, first of all, culture because you can have the best program but if the system is discriminative, it's going to practice you're gonna have the best program, it won't help."

Furthermore, it was consistently noted that ongoing program evolution and adaptation hold significance and merit. One interviewee revealed that overthinking program design could potentially hinder program development. Often, the best approach involves just trying and applying a "trial by error" mentality, which allows mentorship programs to adapt and make changes on an as-needed basis. This practice helps ensure that the program is relevant and adapts continuously based on mentee feedback and the changing STEM landscape to ensure the program remains relevant and effective.

> "Just do it and try it. If you think a lot or if you overthink the whole program, that wouldn't work." "Find some people who will work with you together, who you can rely on, and just start and try it out."

> "I think it is really important that there is no higher hierarchy at all— We work together like kind of a startup thing, where everybody is on the same page – [for example] a person who is more into technical things can also learn a lot from the mentees or from the other people."

Last, a key factor in mentorship relationships that consistently came up was the role of commitment and active involvement from both mentors and mentees.

> "It's always a pity when mentees don't work out. So if the student isn't committing very well to the program, that's really a big loss because there are so few places, and other students would have been very happy to get it."

Thus, program design and the effectiveness of these relationships suggest relying heavily on the participation and engagement of both parties. There are missed opportunities that arise when mentees fail to engage, underscoring the importance of implementing selection processes to ensure that participants are committed and aligned with the goals of the program.

Collectively, the themes stemming from this study highlight the dynamic nature of effective STEM mentoring program design and effectiveness, which often places significant emphasis on the need and importance of facilitating a mentorship space that offers institutional support, tailored mentor-mentee matching to accommodate all learners, adaptability in terms of program structure and the ongoing changing demands on the STEM landscape, and active commitment from all involved parties.

Recommendations

Our interviews revealed key best practices and lessons learned across the case sites, including being adaptable and committed and forming partnerships to foster inclusive mentorship.

> "Having that voice, being visible, being heard, and really just being effective in your overall approach, right? So I think those are very key recommendations. The importance of ambassadors I think it's very important also for successful STEM mentoring.…We looked at different kinds of formats that are possible, such as the workshops, the roundtable coaching, and looking at best practices at other universities."

For example, one participant reported that personalized connections through mentor-mentee matching are highly effective in fostering relationships. Another emphasized aligning mentors and mentees in STEM fields to ensure relevance and deeper understanding. Their program stands out for its approach of connecting mentees with industry mentors, providing real-world experiences alongside academic knowledge.

> "So there should be maybe more... maybe just more programs, because once the mentors remember their study time, and that it was so wonderful to have a mentor, then they are more willing to be a mentor themselves once they're in this position."

The program in Austria takes an approach by reducing entry requirements to encourage participation and creating a collaborative network without hierarchical structures. Effective communication and marketing are prioritized to ensure awareness and engagement. Program4 in Germany highlights the significance of addressing issues and promoting inclusivity, specifically targeting groups such as first-generation students and those who identify as nonbinary. These programs collectively demonstrated the importance of being adaptable, committed, and forming partnerships. They laid a foundation for inclusive mentorship in STEM fields.

Based on insights from STEM mentorship programs in the case study universities, it is recommended that institutions looking to start or improve their own programs focus on several key areas. Enhancing the personalization of mentor-mentee matching by aligning individuals based on their interests, goals, and backgrounds is crucial. This level of matching helps to build relationships. It is also important to bridge the gap between industry experiences by partnering with sectors to provide practical insights. Programs should be designed inclusively and made accessible to groups while accommodating diverse needs.

> "I think one of the most important parts is to bring them in contact with mentors from companies. So from the economic part, from the real, life working people – this is something we keep in mind when we match our mentees that they're kind of in the same professional area [and] that they may be studying the same field."

Effective communication strategies are essential to attract and retain participants. This includes using messaging across platforms. Regular assessments and feedback loops should be implemented to ensure the programs remain relevant and impactful. Creating a supportive environment where experiences are shared is important but also reciprocal.

> It's the effect of the reciprocal process... once you have benefited yourself, give it back, and you become a mentor later... we have postdocs and Ph.D. students in the front field... from physics, chemistry, mathematics, computer science, and geography."

Furthermore, institutional support and leadership involvement are factors for success. This may involve allocating resources, such as having faculty members serve as mentors or advisors. Lastly, expanding the program's reach and scalability by accommodating participants and collaborating with institutions will help broaden its impact.

Limitations

A significant challenge that we encountered included difficulty in engaging with universities in Germany and Austria. We acknowledge that some of this is due to the fact that the researchers are based in the United States, and despite the connections and networks that we have in Europe, this can potentially introduce a level of distrust and uncertainty from those we seek to work with. Despite our continuous efforts, many universities had a low response rate, which affected the scope of our study. This issue suggests a need for further research into why universities in these countries may be hesitant or unwilling to participate in opportunities to share information about their STEM programs, especially when the lack of knowledge that their mentorship programs exist is a known challenge.

To overcome this limitation, we supplemented our research with literature and technical reports. However, it is important to note that relying on case study sites may not fully capture the diversity and breadth of female STEM programs and mentorship initiatives across all international universities, even within these two countries. Another limitation included the decision to maintain confidentiality for our interviewees in hopes that the interviewees would be comfortable and more willing to participate and share knowledge about their personal experiences with STEM mentorship programs. Thus, we did not look into specific details about the mentees and their relationships with their mentors, such as how long they've been working together or how the mentees chose their mentors.

An additional limitation of this study is that it lacks a systematic approach. This study interviewed four individuals, each from a different institution and holding a unique role within their mentorship program. Additionally, these individuals were dispersed across two countries and two distinctly different regions – thus, the findings are not generalizable to all mentorship programs. Another limitation is the study's focus on the mentorship components from the mentor's perspective program rather than capturing experiences from the students/mentees. Furthermore, although our interview captured the perspective of a mentee who later transitioned into a mentor at the admin/management level, this does not reflect a full view of a student perspective. Instead, it highlights a unique trajectory stemming from a successful mentorship program. Future studies could achieve a more nuanced understanding of the dynamics within mentorship programs by interviewing both mentees and mentors. This approach would explore how the experiences of students/mentees influence these programs and contribute to the reciprocal relationship often highlighted in interviews as a key aspect of the mentee/mentor relationship.

Only one student was interviewed, while the remaining three sites involved admin/management-level staff. This does not reflect a full view of the "student" perspective, which is crucial in assessing STEM program success. This part should be noted in "study limitations" more in-depth rather than simply noting a low response rate as one of the limitations since the body of interviewees is also important.

Furthermore, while we took appropriate steps such as triangulation and member checking to ensure the reliability of our findings were in line with academic standards, the limited global reach and low response rates suggest that our conclusions potentially may not fully reflect the worldwide diversity in STEM education and female mentorship programs, in terms of program design and effectiveness. It is worth noting that this study specifically focuses on Austria and Germany. While these countries provide valuable insights, it is important to recognize that their unique cultural, educational, and socio-economic contexts may not fully represent regions. As a result, the generalizability of the findings is limited. It is also essential to acknowledge that those interviewed for this study may not encompass the range of experiences and perspectives

within the STEM community. Qualitative research offers in-depth insights, however, despite this limitation.

While this study only focused on Austria and Germany and found valuable insights into female STEM mentorship programs – the findings presented herein might not necessarily relate to or differ from other global contexts. This is a great starting point for subsequent research to expand upon to capture a comprehensive understanding of the challenges and successes in STEM mentorship, including policy implementation processes across different cultural backgrounds – perhaps on a global level. Since we employed a qualitative interview study approach, our research questions were limited to capturing more quantitative data pertaining to female STEM mentorship programs.

Future research could easily build upon this exact study by conducting a quantitative survey to gather more concrete statistics. This could potentially yield more helpful statistics, particularly regarding the approximate percentage of women in graduate or early career stages in STEM fields who have participated in STEM programs at the university level. This will provide a valuable opportunity to explain the differences (or lack thereof) between various mentorship programs and their settings compared to those in US university settings. Other studies could establish a measurement tool to better assess the level of academic preparation women have when starting these programs, considering the multiple tracks available in K-12 education in other countries, including the United States.

Discussion and Conclusion

Women continue to be underrepresented in various STEM fields, encountering systemic barriers that hinder their advancement and leadership opportunities. Closing this gender gap is not a matter of fairness; it is crucial for harnessing the potential of talent and fostering innovation in these critical areas. Our findings show that tailored mentorship programs at universities focusing on STEM can play a role in bridging this gender gap. These programs pair professionals with young women, offering them essential guidance, networking opportunities, and skill development to navigate the often-challenging landscape of STEM careers.

Our conversations with mentors at universities in Austria and Germany helped shed light on the mentorship program effectiveness, program design, best practices, and lessons learned in addressing the overarching issue: the gender disparity within STEM fields. The motivation behind our analysis is driven by identified research gaps that highlight the need to evaluate the efficacy of these programs in tackling the problem statement: reducing the gender gap that exists within STEM fields. This study captures both the positives and challenges within STEM mentorship programs for women. While there are best practices and initiatives, we must also

address significant obstacles. As one of our study participants stated, "No, I think there are just not enough mentoring programs."

Continuous research in this field is crucial. Future studies should focus on strategies to increase mentor engagement by exploring incentives and support systems that encourage professionals to participate. Additionally, enhancing awareness of these programs through social media utilization, industry partnerships, and alumni networks is essential to expanding their reach and impact. The mentorship programs implemented in universities in Germany and Austria showcase an understanding of the methods and obstacles involved in STEM mentorship. By comparing and contrasting their structures, strategies, and outcomes, we can gain insights into what constitutes a mentorship experience in STEM fields, especially for women and underrepresented groups.

Furthermore, future studies could build upon this study's findings and examine the long-term impacts of mentorship programs. Other avenues could explore similar mentorship issues in different STEM fields or perhaps geographical areas. This not only adds to the scholarly value of female mentorship programs but also encourages continued exploration in this important area via best practices and lessons learned. Continued research on this pivotal topic allows for a more comprehensive, globally relevant, and practically applicable contribution to the field of STEM education and gender equality.

Our case studies have identified several effective strategies that, when implemented as best practices or taken as lessons learned, could potentially foster gender equality in STEM on a global scale. These strategies emphasize the importance of adaptability via implementing and maintaining a tailored and personalized approach is important as it accommodates mentees' goals and objectives. Commitment, suggested to be vital, with strong leadership buy-in and sustained institutional support at all levels, was shown to be an important component of facilitating mentorship programs and increasing mentee engagement. Personalized matching that pairs mentors and mentees with compatible skills, interests, and career goals was seen as an effective strategy to maintain mentee engagement. Outreach and awareness were other strategies commonly used across case sites. These components were strategies employed via training workshops that equip educators, mentors, and administrators with the skills to facilitate successful mentoring relationships. Furthermore, organizing webinars, conferences, and kick-off events were seen as vital components to attracting mentees to the mentorship program and demonstrating the value that stems from such opportunities via knowledge sharing and networking opportunities for mentees to connect.

Taken together, in the realm of mentorship programs and gender equality in STEM – our research highlights that mentorship size doesn't matter, nor does the length of how long a program has been established. What matters is the mentorship programs’ willingness to be open to cultivating a supportive environment that welcomes women from diverse backgrounds and

experiences and uses that space to foster a reciprocal mentee-mentor relationship. A space that is adaptable, flexible, and personalized seemingly enough provides access to resources and networks, as well as creates unique connections and opportunities that may not have always been readily available – a formidable force for positive change, shaping a more equitable landscape for women pursuing careers in STEM globally.

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