Women in AI: Barriers and Solutions

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Abstract*— The inclusion of women into the development and implementation of artificial intelligence and machine learning in the world is critical. The underrepresentation and lack of representation of women results in lower quality AI products. The AI consumer group is very diverse and the lack of diversity within the AI leadership and workforce creates a crisis within the AI industry. Additionally, because AI is fast-paced and has a high societal impact, not addressing this disparity has the potential to increase stereotypes, underrepresentation, and discrimination in career fields everywhere. This paper discusses the importance of women in the AI field, the barriers that they face, and a few solutions to eliminate gender-discrimination and gender-inequality for women of all ages. Women may experience increased discrimination in fields of underrepresentation, and this can discourage their desire to purse these career paths. The workplace needs to be aware of these struggles, provide resources for both men and women to address this, and invest in support for women to encourage their participation. As an emerging industry, the AI industry has an opportunity to address this gender gap before it becomes more pervasive and ingrained into the culture of AI. Together, we can have a significant impact on the future of AI, the community, and the products that consumers use.

Keywords—Women, Artificial Intelligence, Barriers, Solution, Diversity

I. INTRODUCTION

Women in the artificial intelligence (AI) field are shaping gender relations, tackling new challenges, and advancing new and other opportunities for more women [1, 2, 9]. To fully integrate women into the field, women need to be involved in the design, implementation, evaluation, and debate on ethics and norms for promoting diversity in the artificial intelligence and machine learning field [10]. Involving them in such tasks promotes not only their personal and professional growth but the growth of their team and therefore the growth of technology [3]. The inclusion of women in all avenues will lead to policies and practices that make equality in the digital world a reality. However, such a task means the men that make up the majority of the artificial intelligence field need to work as allies and proactively change the workplace from the inside out to make AI an inclusive environment for all [4].

A. AI and importance for the future

AI is a quickly growing field with its economic impact expected to reach $15.7 trillion by 2030 [11]. However, even with its rapid growth and success, the AI field is experiencing a critical diversity crisis. As AI expands and becomes a normal part of the human experience for medicine and self-driving cars, the field continues to be underrepresented by women. Only 14% of AI researchers globally are women and even less of the field is represented by people of color with black and Hispanic men making up only 11% of researchers [11]. Due to this lack of diversity AI products can be biased and can have a variety of effects from not serving everyone to actively harming underrepresented groups. There is evidence that the existing biases, sexism, racism, and other discriminations are built into AI intentionally and unintentionally [5, 6]. It is crucial and fundamental to the development of the field that AI become a more diverse field to guide the development for success in the future [11].

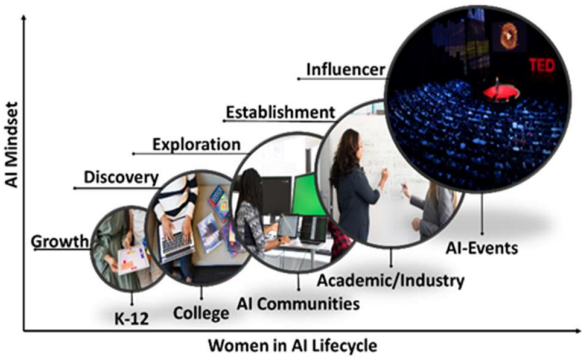

Fig. 1. Evolution AI-Mindset in Women Lifecycle

The current gap in AI not only exists in industry but also in academia and continues to widen. The number of women in AI in 2013 was 26% below the number of women in AI in 1960 and almost half the women that enter technology fields leave. Of the leading AI conferences only 18% of authors are women and 80% are male [7]. This imbalance in academia and industry leads to an imbalance at large tech firms such as Facebook and Google where an even greater lack of diversity is shown with only 15% and 10% of AI research staff being women, respectively. AI is a subfield of computer science which is historically a male-dominated field. Only 18% of all computer science majors are women which is a decline from 37% in 1984 [7].

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B. Challenges involving women in AI

There are several layers within the artificial intelligence field that contribute to the lack of diversity. The first problem is the lack of role models and a culture where women feel welcomed within the field. The lack of role models, who could directly impact shaping the next generation of engineers and computer scientists is problematic and contributes to stereotypes that currently impact the recruitment of young talent into AI [6]. There is also a disconnect between the deployment of the technology and the social, economic, and political impact artificial technology will have on all humans. Another challenge women face is the effects that digitizing the workplace will have on the future of work and advancement opportunities for women [4].

To encourage women to pursue careers and goals in the AI field organizations like Women in AI (WAI) were founded. Women in AI is a nonprofit do-tank working towards gender-inclusive AI that benefits global society. The organization states, "Our mission is to increase female-identifying representation and participation in AI." The organization focuses on bringing empowerment, knowledge, and active collaboration via education, research, events, and blogging to the women in the community [11].

C. Women in AI and their impact

It is imperative that women entering the field of AI have role models that are: i) leaders that strive for change, ii) driving their own career and iii) committed to rising to the top. Role models with these attributes show women the possibilities of entering the field and give them hope of becoming more successful. To continue to diversify the field of AI, women need to be able to look to other women for guidance and assurance that the world of AI is a place for women.

There are a variety of characteristics that make someone a good role model. Whether it is innovation, leadership, creativity, or education, the future women in AI have a variety of women to look to when searching for role models. Women role models in AI often showcase their leadership skills which assists in building their confidence in this male-dominated field. Leaders practice self-reflection to improve themselves and their work. They set standards for themselves, their coworkers, their teams, and their students. Although they are leaders, women in AI who have this characteristic show empathy and think carefully about the impact they have on others, as leaders. An example of someone with these qualities is Mansi Gupta. After graduating from Carnegie Mellon University with a master's in computational data science, Mansi developed skills that projected her forward to become a Machine Learning Engineer for Petuum. She then became the Senior Machine Learning Engineer at Twitter where she writes algorithms for Twitter that help to surface trends and recent events and rank them & group them with other useful information [8].

Another characteristic of a women role model in AI is someone who is an innovator. Women who are innovative think in new and nontraditional ways, which leads to new devices that are compatible with women and others who are not represented. Women with this characteristic strive for change in new ways. Francesca Donadoni models this characteristic. Francesca has a master's degree in Engineering from Imperial College London and completed a Ph.D. in Biomedical Engineering last year at UCL-London's Global University. She has spent time this year improving her skills in Data Science, Python, and Computer Vision through courses with IBM and Udacity, and has secured a new position as a Machine Learning Engineer with Arthronica, where she supports patients with rheumatoid arthritis in their treatment and recovery, by developing the machine learning infrastructure [8].

Women role models can be educators. These women strive to make more AI programs for girls at different levels of education from K-12 to higher education. They want to teach and inspire future generations to pursue the field. Diyi Yang is an educator who has become a role model for many. Diyi gained experience early in her career at Microsoft & Facebook before joining Google as a Postdoctoral Researcher. She now works as an Assistant Professor at Georgia Tech and directs the Social and Language Technologies Lab. She currently is integrating her research in social sciences and linguistics with machine learning to program computers that facilitate online social interactions [8].

TABLE I
BARRIERS FOR WOMEN IN AI

Barrier Type	Description	Solution
Misconceptions about Socio-Cultural Expectations and Structure	Gender-Specific Expectations: Twice as many boys as girls expect to become engineers, scientists, or architects. Gender gap in entrepreneurship: Men are nearly twice as likely as women to be self-employed; they are three times more likely than women to own a business with employees	Changing gender-specific expectations about professions is key, including fostering female-identifying role models in AI. Narrowing the gender gap calls for actions addressing the structural root causes of the divide. Implementing awareness campaigns that tackle socio-cultural norms and biases and stereotypes
Lack of Education	Women are less likely than men to participate in massive open online courses related to AI, which can often be accessed for free and cover a range of topics. Lower proportions of women graduate in AI. Also, when women graduate in these fields and go on to the labor market, they display on average lower numeracy skills than male graduates.	Encouraging greater female-identifying enrolment in AI-related studies and apprenticeships; and targeting existing gender biases in curricula and parental preferences. Creating and funding grant schemes aimed at enhancing the enrollment of women in AI education
Lack of Diversity	Lack of diversity in the composition of AI teams across the world reflects widespread gender gap and consequently socio-cultural gender biases and discrimination	Female-identifying participation in AI activities should be increased at a faster pace. However, success at increasing the number of girls and women studying AI will do little to bridge gaps if these people confront unchanged biases in the workplace

II. BARRIERS FOR WOMEN IN AI

There is no denying the fact that women are underrepresented in technology and AI. It is estimated that only 13.5% of professionals working in AI are women. This begs the question of why. At the dawn of computers and the internet, many of the leaders and innovators were women, however, today there is an overwhelming male presence in this field. Even the large software companies have astonishingly low percentages of women working for them: Google AI has only 10% and Element AI has only 12% [8]. Many companies do not believe that women produce an increase in financial return and 2/3 of them believe women will put their families before their jobs more than men [20]. Table I illustrates a few of the barrier's women face in AI along with some solutions to eliminate gender inequality. Transformation in the gender gap will only happen if large steps are taken, especially by male-identifying leaders in companies and government to create a culture of equity. Some of those steps could be thorough visible leadership and advocacy for change, educating to alleviate unconscious bias, offering blind recruitment and pay, offering sponsors instead of mentors, sanctioning flexible hours for all, and realizing that men can, do and should be allowed to focus on their families [20]. Table II identifies these solutions, which are categorized based on the underlying barrier for each identified gender-gap. Each solution is specific to the problem and gives descriptions of why these barriers cause such a problem.

A. Breaking Barriers Women in AI

Influential women can provide girls the motivation and inspiration to achieve their own goals. When there is a lack of women leaders in AI, aspiring women leaders in AI may not feel that it is possible for them to advance because they don't see other current women in those roles. Visible women leadership is imperative [8]. The Peterson Institute for International Economics completed a survey of 21,980 companies in over 90 countries and found that "the presence of more female-identifying leaders in top positions of corporate management correlates with increased profitability of these companies" [9]. Some examples of women in technology who have broken barriers and serve in leadership roles can be seen in Table II. These are women who have overcome gender bias and discrimination and are now thriving. They are leaders in their field and pioneers for women in AI [8]. Women like Daniela Rus, one of the world's leading roboticists, are revolutionizing AI as we know it. She is conducting groundbreaking research into advancing network collaborations, self-reconfigurable, and soft robots [10]. Heather Bowerman is using her position to help eliminate systematic bias in the medical field to bring about equality for all. She was named one of the top innovators under 35 in 2016 by MIT Technology Review and named one of the most intriguing entrepreneurs in 2017 by Goldman Sachs [31]. These are only a few of the women changing AI for the better and working to make the AI field more gender inclusive.

TABLE II
BREAKING BARRIERS WOMEN IN AI

Name	Title	Company	Breaking what Barrier
Heather Bowerman	Founder and CEO	DotLab	First non-invasive test for endometriosis
Ahna Girshick	Senior Computational Research Scientist	AncestryDNA	Improved data visualization design and developed computational approaches to connect people to their history
Rana el Kaliouby	CEO and Co-Founder	Affectiva	Developed machine learning technology capable of emotions now used by 25% of the Fortune 500
Daniela Rus	Professor and Director of CSAIL	MIT	First female-identifying head of MIT's CSAIL
Rachel Thomas	Founder	Fast.ai	Provides AI free online courses to all

B. Suppotive Organization for Women in AI

To assist with gender equality transformation in AI, there needs to be more devotion by all in the AI industry to promote, develop, and mentor women. Table III shows a few examples of entities whose main goal is to help close the gender gap in technology. AI4ALL and Women in AI are two companies who are working directly in AI. Girls Who Code and Women in Technology are two organizations dedicated to supporting women in technology. All four of these organizations believe in the impact women have and the importance of their representation and participation in technology. AI4ALL offers summer programs and courses for underrepresented women to help them develop mentor relationships and gain confidence in their knowledge of AI [11]. Girls Who Code offers a similar summer program; however, they are most prominent in colleges and schools through after-school clubs and what they call College Loops. The after-school clubs are for girls in 3rd through 12th grade. They offer a safe and exciting environment for girls to explore coding. Their College Loops are a great way to help alumni network with other women and succeed in life past college [12]. Women in Technology offers job fairs, community programs, and award ceremonies for women in professional technical careers [13], and Women in AI offers conferences and event challenges for women in the workforce as a means of learning and networking [14].

C. Solutions

In order for there to be gender equality within technology, and specifically in AI, there needs to be significant changes. Women need to see and feel the difference. Table IV proposes a career life cycle recommendation for women in AI. This life cycle is broken into phases based on age and where women are in their

career. The life cycle focuses on education, mentors, and resources being made available and, in some cases, required for all. While in K-12 schools, the focus on supporting girls is focused on changing the curriculum to make it more inclusive. During undergraduate education women are often in a discovery phase, and the current solutions focus on inclusion and inspiring women through events and education. In the early stages of a woman's professional career, she will be trained and exposed to diversity initiatives to ensure she feels welcome. In the middle stages of a woman's professional career, the focus is on making the career work for her and giving her the opportunities, she needs to advance in her position, Figure 1.

TABLE III
SUPPORTIVE ORGANIZATION FOR WOMEN IN AI

Organization	Vision for AI	Program Goal
AI4ALL [11]	Diverse and inclusive workforce: AI provides a powerful set of tools that everyone should have to access our fast-changing world. Diversity of voices and lived experiences will unlock AI's potential to benefit humanity.	Connect all minorities to women role models and mentors. Currently, 86% of alumni have female-identifying role models in the AI field.
Girls Who Code [12]	Stop the decline: the percentage of women in computing is declining and Girls Who Code hopes to stop the decline and eliminate the gender gap.	Change the image of how the world views programmers and close the gender gap within technology-based careers.
Women in Technology [13]	Provide opportunity for learning: offer leadership development, technology education, and mentoring opportunities to all women in technology, including AI.	Women in technology's main program goal is to help advance women in technology in all aspects of life.
Women in AI [14]	Empowering women in AI: women need to be represented more in AI and the stigma of fear and threat in the field needs to be eliminated. Women need to be supported in leadership roles and in pursuit of greater influence.	Women in AI's main program goal is to close the gender gap for women in AI both in representation and participation.

Finally, women will need to be given access to programs and education to keep them up to date and encouraged in their fields. This life cycle proposes a new means of offering opportunities for women and gives them the support they need to succeed.

TABLE IV
RECOMMENDATION FOR MAKING AI-MINDSET FOR WOMEN

Age	Phase	Recommendation
>18	*Growth*	AI Education in core curriculum Unconscious bias training for teachers and counselors Girls in AI role model (in the media)
18-24	*Discovery*	AI events and programs More women professors Build awareness about AI industry jobs
25-34	*Exploration*	Visible women role models Diversity in hiring Training Male allies
35-54	*Establishment*	Professional skill development Policies on workplace diversity Childcare program at work Technical training
55-64	*Influencer*	Industry conferences and women - specific programs Increasing online access to education Encouragement from management

III. ENTREPRENEURIAL MINDSET FOR WOMEN IN AI

Entrepreneurs are not born; they are driven by their passions and their choices to create. An entrepreneurial mindset is defined as a way of thinking that enables one to overcome challenges, be decisive, and accept responsibility for outcomes [17]. This mindset is imperative in AI because AI is a relatively new career field and is growing at warp speed. Some of the best AI innovations are yet to occur. New creators and innovators are needed to test the boundaries and challenge the existing usage of AI. The biggest deterrent of an entrepreneurial mindset, however, is lack of confidence [17]. Doubt in one's ability can cause a negative downward spiral for any entrepreneurial dream. No matter the misstep or negative outcome, persons with an entrepreneurial mindset will accept the consequence, learn from it, and grow. They do not get stuck and give up [18]. The AI workplace is not always accepting and welcoming towards women and, therefore, does not necessarily cultivate building confidence. It is more difficult for women to attain this mindset because of the lack of support from both male- and female-identifying co-workers. If AI is to develop and reach its full potential, diversity in ideas and creativity is needed. This means diversity in the people creating AI implementations. Support needs to be given to those with new ideas and stereotypes need to be negated for project completion. Encouragement towards women in the AI field can help to solidify their confidence, and in turn, their work which will lead to great strides in AI and in technology [19].

IV. FUTURE CHALLNGES FOR WOMEN IN AI

The fate of gender equality in AI and technology lies in our collective hands. We, men and women alike are responsible for eliminating the gender gap and to create equal opportunities for all women. If change is not made, and soon, there will be devastating effects on AI. Table V describes some of the struggles the we will endure if gender equality is not achieved soon. These problems have large side effects and could cause a complete loss of the hope for technical careers to ever have adequate representation and participation of women. Stereotypes will only continue to dominate the way AI is viewed and women will lose any sense of belonging they once had [21]. The percentage of women in the computing field is decreasing and the pay gap is getting larger every year. With 74% of women working in computing

reporting gender discrimination or harassment, those percentages will not change on their own [15]. It is up to all of us to make it happen.

V. Women in AI at University of Wisconsin-Platteville

UW-Platteville has a long history of supporting Women in STEM and specifically, in 2017, implemented a Girls Who Code Club and in 2018, an ACM-W student section. The particular additions highlighted the support of Women in AI on the campus. The UW-Platteville Girls Who Code Club is an extension of the International Girls Who Code Club established in 1995. The program is directed by computer science Professor Donna Gavin and financially supported by local grants and the Women in STEM Program. The free Platteville Club is held after school for girls and young women in grades 6-12 and takes place weekly during the school year for 1-2 hours each night. UW-Platteville college women support the program as mentors under the direction of Professor Gavin, providing a "sisterhood of supportive peers and role models using computer science to change the world." The international organization provides training, project-based curriculum, and ongoing support to program directors. Club participants brainstorm ideas on problems they would like to solve in their communities such as fighting climate change, combatting bullying, and getting out the vote. Over time, the participants work with various tools such as Arduino's, micro bits, wearable technology, and Raspberry Pis. At the end of the academic year, the participants present their projects in an exposition showcasing their efforts and confidence with coding! The Club has been highlighted in various local newspapers and news interviews on television. Since starting the club some of the coding experiences were also including in additional, short, hands-on activities offered by the Women in STEM Program for middle and high school girl events to encourage participation in STEM. During the pandemic, Professor Gavin was able to continue the club virtually. The coding, multi-level mentoring, the focus on addressing social issues, and the exposure in media all help to create interest in coding.

The addition of the ACM-W student section on campus helped to both provide support to the Girls Who Code Club and the women students in the software engineering computer science programs at UW-Platteville. Many of the ACM-W members participate as mentors in the Girls Who Code Club. The connection between serving as a role model for girls and young women and also supporting each other as college students is critical in helping women see that they too belong in computer science, software engineering and AI. Besides supporting the Girls Who Code Club, the ACM-W members participate in social events, networking events with women in industry and also spend time learning technical skills. The combination of both the ACM-W student section and the Girls Who Code Club are just two examples of many where UW-Platteville Women in STEM supports women in AI.

VI. Discussion and Conclusion

There is a legitimate concern that women will lose jobs due to automation at a higher rate than their male counterparts. According to Holder, nearly 50 percent of all occupations in the United States are at risk of being replaced by AI or machine learning by 2026. In addition, the scholar notes that while female-identifying workers make up only 50 percent of the workforce and up to 58 percent are at the highest risk of being replaced by automation. The implication of this research is that women need to learn new sets of skills to be employed. In the United States, almost 25 percent of women currently employed might find their livelihood upended by technology advancement in the current decade (2020-2030) [28]. While men will significantly be affected as a result of AI, female-dominated professions will be affected at a higher rate; therefore, it is imperative that initiatives be taken to ensure women learn new skills to prepare them for the new technological market and ease their way into the jobs of the future.

TABLE V
FUTURE CHALLENGES FOR WOMEN IN AI

Type	Future Challenge for Women in AI
Bias and Discrimination	Discouraging young girls from pursuing AI Family, parents, teachers, and advisors telling girls they are incapable
Personal Barriers	Lack of self confidence Intimidating to work with older men as a young woman. You do not know where to start and who to talk to
Resources and supports	Difficult to find a core group of relatable friends and support groups. Lack of parental support and encouragement Lack of visible icons, heroes, and mentors Lack of male-identifying voices for equity
Education	Gender biases from early education (toys, media) Lack of AI introduction in elementary and middle schools Not recognizing that technology should be a mandatory learning area. Narrow-minded focus of AI on gaming and programming

As with the rest of the technology industry, the presence of women in the field is significantly overshadowed by their male counterparts [26]. As the job market in AI increases, this gender gap suggests a window of opportunity for women seeking to begin a career in the field of technology or change pathways in the already established technology careers. To achieve the steadily increasing demand for more AI professionals, talent pools in AI must be targeted to include candidates from both gender, ages, and backgrounds, among others [25]. A recent study conducted by Gilchrist found that the AI jobs market is expected to increase up to 16 percent in 2021. As the AI job market expands, so does the opportunity for women.

To prepare for this future growth in the AI industry, relevant stakeholders must work to gain the interest of young female-identifying students in Science, Technology, Engineering and Mathematics (STEM). According to Madgavkar, Anu, et al [23], only 13 percent of female-identifying university students graduated in STEM related fields, while their male counterparts had a rate of 29 percent. As AI takes over more of the employment market, it is essential for both women and men to be educated in STEM fields. Women, however, face pervasive hindrances compared

to their male counterparts, and will need targeted support to progress in this world of work. It is imperative to motivate and encourage girls to study STEM from a young age [30]. This early entry into the field will open doors for opportunities to pursue careers in AI; therefore, STEM education targeted at girls will be key to increasing the number of female-identifying workers in the AI sector in future.

Women will also have a significant impact in emerging AI markets. Well established and diverse companies such as Google face a common challenge of capitalizing on the explosive growth in emerging markets, and to succeed, they must commit themselves to recruitment, hiring, and retention of top talent in these emerging markets [28]. This is not a simple task, turnover in many emerging countries is disproportionately high. To address this issue, a majority of the leading global companies have utilized a source of talent that is usually overlooked by rival companies: women in the emerging countries who represent at least half of university graduates and workforce [29]. In the coming years, AI is set to disrupt employment patterns massively and companies and other stakeholders must thus be prepared to invest in reskilling for AI-related jobs. Companies can take a thoughtful approach and utilize these emerging AI markets to minimize gender-bias in workplace hiring, retention, and career growth, which could work to propel women on the path to leadership in these emerging markets.

Automation is also expected to shape the life of women at home. As Voiculescu [29] affirms, automation is transforming the economy and is radically changing the working lives of women for the better, provided they have the required skills to work alongside machines and shift into new occupations as their jobs are replaced. Although most of the research on women and AI is focused on how AI and machine learning can affect the female-identifying workforce, there are many ways that AI influences the lifestyles of women at home; from security to interior design [21]. While it may be difficult to figure the extent to which AI will affect women at home, women will be living in a world of incredible technology. As women disproportionately handle the care of children and elderly parents, time to reskill in new sectors is rather limited, but as AI continues to infiltrate the modern home, this will relieve them of some of the menial tasks and allow more time to focus on developing new skill sets [23].

In a future dominated by AI, companies will need to diversify the skillsets among their top leadership to stay fresh in the market. A leadership board dominated by white men will simply not understand the needs of women. This gap should allow for more women to grow into leadership roles as companies recognize the need to embrace diversity. Women bearing witness to the success of other women could in itself attract more women to the field of AI. As men continue to dominate the leadership roles, women are fighting to equalize the playing field, and seeing the success of others may serve as great encouragement. Ruth Bader Ginsburg famously said "I'm sometimes asked when will there be enough [women on the Supreme Court] and, I say, when there are nine, people are shocked. But there'd been nine men, and nobody's ever raised a question about that." Providing women with the opportunity to advance in their careers and leading them to success in senior leadership roles can be an efficient way to attract women into the technology workplace [21]. Companies can encourage female-identifying workers through promotions to senior management roles, which will be inspiration to new entrants and future candidates to pursue careers in the field. Transformational women leaders are role models for young female-identifying professionals and are influential to women in technology. Women in senior management positions can positively influence female-identifying employee involvement and retention of top women talents.

The minimal female-identifying participation level in the development of AI continues to be a major issue of concern. Women's concerns and approaches have the potential to shape the development of AI. It is important to take into account the germane factor that will influence overall technology operations with all the information and news about the significance and take-over of AI [27]. The impact of the low participation level of women in AI development is that the feminine blending needed to augment day-to-day life will be non-existent in AI [24]. Therefore, if this issue is not addressed, the pervasion of AI might be viewed negatively, which would have a devastating effect, as the importance of women's input cannot be excluded from AI development. Women will ensure that the AI industry has a diverse perspective and will encourage innovative ideas and outcomes of AI technology, and its considerable effect on day-to-day lives [27]. Overall, the significance of the female-identifying perspective and involvement in AI development is critical in the future of AI.

Narrowing the gender gap in the technology field is essential for many reasons, the most important one being establishing and sustaining genuine equality and access to opportunity, regardless of gender. Society is at the crux of an impasse. As AI continues to develop and infiltrate every aspect of daily life, AI can serve to close the gender gap or widen it. Concerted efforts must be made to encourage young girls to pursue a future in STEM, promote women to leadership roles within the AI industry, and to consider the needs of women when developing new technologies. With these efforts realized, AI can be a powerful equalizing tool.

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