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Navigating the Confluence of Inequality and STEM Equity: An Australian Perspective

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ABSTRACT

This study underscores the chronic issue of gender pay disparity that prevails across different STEM fields and educational qualification levels in Australia. Despite instances where women's incomes may align or even surpass men's, the broader pattern of inequality remains undeniable. The study advocates for targeted strategies to address gender pay gaps, particularly in fields like Engineering and Science, and emphasises the significance of cultivating inclusive work environments that recognise and reward contributions regardless of gender. This study serves as a critical call to action to rectify these inequities and promote a more balanced and equitable STEM landscape.

KEYWORDS

Inequality; STEM Equity; gender pay gap; Australia

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1. Background

There are strong connections between gender inequality and STEM equity in Australia. Gender inequality refers to the unequal treatment and opportunities individuals face based on gender. STEM equity, on the other hand, focuses specifically on achieving gender balance and equal opportunities in STEM fields.

In the case of Australia, gender inequality is evident in various aspects of society, including education and the workforce. Historically, women have been underrepresented in STEM fields in education and professional settings. This underrepresentation is a result of various societal factors, stereotypes, and biases that discourage girls and women from pursuing STEM education and careers. YouthInsight's Youth in STEM survey found girls' confidence in STEM subjects worsened as girls progressed from their teenage years into adulthood (Department of Industry, Science and Resources, 2022). At 22-25 years of age, only 55% of women reported confidence in Science, 56% in Technology, 27% in Engineering, and 50% in Mathematics.

The dynamics of inequality and equity within Australia's STEM (Science, Technology, Engineering, and Mathematics) landscape intersect in intricate ways, presenting a multifaceted challenge to achieving balanced representation and opportunity. These intersections encompass gender disparities, where women remain underrepresented in STEM fields due to persistent biases and the scarcity of female role models.

Socioeconomic inequities exacerbate the divide, limiting access to quality education and resources for students from disadvantaged backgrounds. Moreover, the nexus of Indigenous representation and STEM equity reflects historical and cultural complexities, resulting in marginalised Indigenous populations having limited access to STEM education and careers. Geographical factors also play a role, as regional disparities hinder STEM engagement in rural and remote areas due to inadequate resources and opportunities. The interplay of cultural and linguistic diversity introduces additional hurdles for individuals from multicultural backgrounds, often encountering language barriers and cultural biases (Howcroft & Rubery, 2019).

Inclusion and accommodations for disabled students further highlight the need for a comprehensive approach to STEM equity. Unconscious bias, both in recruitment and in workplace dynamics, perpetuates unequal representation, while policy and funding disparities across states can exacerbate existing inequalities. The concept of intersectionality amplifies these challenges, as individuals often face layered barriers based on gender, race, socioeconomic status, and more. Addressing these intricate intersections necessitates a holistic strategy that encompasses policy reforms, cultural shifts, community engagement, and educational overhauls. By cultivating gender equity, fostering inclusivity, providing mentorship, and challenging biases, Australia can navigate the complex intersections of inequality and STEM equity to foster a more diverse, inclusive, and equitable STEM landscape.

One of the main connections between gender inequality and STEM equity is the lack of representation of women in STEM fields. This begins early in education, where girls are less likely to choose STEM subjects in school. As a result, fewer women pursue higher education in STEM-related fields, leading to a gender imbalance in STEM occupations.

STEM has become a focus for economic development strategies and investment to drive growth and support quality of life outcomes, with a myriad of programs and initiatives offered nationally (McKinnon, 2022). Australia's STEM workforce has grown rapidly from approximately 1,353,295 in 2016 to 1,659,649 in 2021 (Department of Industry, Science and Resources, 2023). The National Skills Commission has predicted STEM jobs to grow a further 14% by 2026, twice as fast as non-STEM jobs (National Skills Commission, 2022). However, the STEM workforce faces challenges, particularly in equality and diversity, which can inhibit sustainable growth in these industries. In Australia, women are underrepresented in some STEM clusters compared with their share of the overall workforce.

In this context, the emphasis on STEM as a focal point for economic development strategies and investment to drive growth and enhance quality of life outcomes is both timely and consequential. This shift in focus is a response

to the changing global landscape, where technological advancements and innovation play pivotal roles in shaping economies, industries, and societies.

Australia's investment in STEM aligns with the recognition that these fields are fundamental drivers of innovation, productivity, and competitiveness. The nation's economic growth is intricately linked to its ability to develop and deploy cutting-edge technologies, create high-value industries, and remain adaptable in a rapidly evolving global market. Consequently, the strategic prioritisation of STEM in economic development strategies is aimed at ensuring Australia's continued relevance and prosperity in an increasingly digital and knowledge-based economy.

The significance of STEM extends beyond mere economic considerations. As Australia strives to maintain and improve its quality-of-life outcomes, STEM education and innovation offer solutions to pressing challenges across sectors such as healthcare, environment, energy, and infrastructure. Investments in STEM research and education contribute to advancements in medical treatments, sustainable energy solutions, efficient transportation systems, and improved resource management, directly impacting the well-being and quality of life for Australians.

Fostering STEM expertise and cultivating a culture of innovation enhances workforce capabilities. A skilled STEM workforce is not only essential for driving technological breakthroughs but also for creating jobs, attracting foreign investments, and supporting industries that rely on specialised knowledge. The growth of STEM-related industries, such as artificial intelligence, biotechnology, and renewable energy, not only generates employment opportunities but also positions Australia as a global player in emerging markets.

Australia's vast and unique natural environment offers a wealth of opportunities for innovation, particularly in fields like agriculture, environmental management, and mining. Applying STEM principles to these sectors can lead to sustainable practices, greater resource efficiency, and reduced environmental impact, contributing to the nation's commitment to environmental stewardship and sustainability.

However, the efficacy of prioritising STEM in economic development strategies hinges on several factors. Effective implementation requires collaboration between academia, government, and industry, ensuring that STEM education is aligned with industry needs, and research addresses real-world challenges. Additionally, strategies must consider inclusivity and diversity to ensure that opportunities in STEM are accessible to individuals from all backgrounds and walks of life.

This study underscores the chronic issue of gender pay disparity that prevails across different STEM fields and educational qualification levels in Australia. The study also advocates for targeted strategies to address gender pay gaps, and emphasises the significance of cultivating inclusive work environments that recognise and reward contributions regardless of gender.

2. Role of Educational System

Educational systems play a key role in shaping the future of the STEM workforce and diversity. Findings from the World Economic Forum's Global Gender Gap Report 2021 corroborate the underrepresentation of females in STEM higher education enrolments (World Economic Forum, 2021). In 2022, only 27% of STEM students were women, with the largest gaps in the fields of and Engineering and Manufacturing (Australian Bureau of Statistics, 2022). These statistics are problematic given that the Australian Government regards high-quality STEM education as critically important for our current and future productivity, as well as for informed personal decision making and effective community, national and global citizenship (Department of Education, 2023).

The STEM Equity Monitor Report found that gender disparity for STEM subjects is evident within youth systems and continues throughout higher education and employment (Department of Industry, Science and Resources, 2022). Among 12–17-year-old youth, girls considered all STEM subjects to be less important for getting a good job compared with boys. Girls also demonstrated lower confidence in STEM subjects than boys, particularly

in the areas of engineering and technology. Among tertiary education STEM enrolments, only 37% of university enrolments were female. Women's career pathways following STEM education also demonstrated challenges with retention. Only 29% of women with STEM qualifications worked in a STEM occupation, compared with 37% for men. This suggests a greater need for more informal pathways into STEM, particularly programs that organically build knowledge and skills (Hinojosa, Swisher & Garneau, 2021).

3. Pay Gap and STEM Qualifications

In 2021, women made up 27% of the workforce across all STEM industries, a decline from 2020 where the proportion was 28%. Hoobler, Lemmon and Wayne (2011) suggest that industries with underrepresentation of women in upper management positions correlate with females less likely to enter that industry. STEM industries have low representation of females in leadership positions. This is reflected in the STEM Equity Monitor, where women make up 23% of senior management positions and only 8% of CEOs (Department of Industry, Science and Resources, 2023).

In addition to being underrepresented in STEM, women are also underpaid. The gender pay gap in STEM industries is higher than any other industry. Overall, women's average full-time income in STEM industries is 17% lower than men's in STEM-qualified workspaces across all industries in 2022 (down from 18% pay disparity in 2021) (Department of Industry, Science and Resources, 2023). This gender pay gap is less than the average across all industries, where women's full-time income is 19% lower than men's income. In 2022, full-time median incomes for women were lower than men in three of four VET STEM graduate fields, two undergraduate STEM fields, and four postgraduate by coursework STEM fields (see Table 1).

Table 1. Women's full-time median income by qualification type, Australia, 2022.

Field of Study	STEM VET qualifications	Undergraduate STEM Qualifications	Postgraduate STEM Qualifications
	Women's full time median income		
Agriculture and environmental studies[1]	$50,000 ($7,000 less than men)	$70,000 (equal to men)	$80,000 ($3,000 less than men)
Engineering[2]	$60,000 ($10,000 less than men)	$71,000 ($1,000 less than men)	$88,000 ($17,000 less than men)
Computing and information systems[3]	$62,000 ($2,000 more than men)	$69,000 (equal to men)	$95,000 ($9,000 less than men)
Science and mathematics[4]	$50,000 ($10,000 less than men)	$65,000 ($2,000 less than men)	$89,000 ($10,000 less than men)

Table 1 provides a breakdown of women's full-time median income in various STEM fields of study across different educational qualification levels. It also compares these median incomes to those of men. This analysis sheds light on the gender pay gap within STEM disciplines and underscores the disparities that exist within different fields and educational levels.

[1] Denoted as 'Agriculture, environmental and related studies' for STEM VET qualifications.
[2] Denoted as 'Engineering and related technologies' for STEM VET qualifications.
[3] Denoted as 'Information technology' for STEM VET qualifications.
[4] Denoted as 'Natural and physical sciences' for STEM VET qualifications.

3.1. Agriculture and Environmental Studies

In this field, women with VET (Vocational Education and Training) qualifications earn $50,000, which is $7,000 less than men. Among those with undergraduate STEM qualifications, women's median income is $70,000, equal to that of men. However, for women with postgraduate STEM qualifications, their median income of $80,000 is $3,000 less than men. This suggests that while gender parity exists at the undergraduate level, there is still a pay gap for women at the postgraduate level.

3.2. Engineering

The gender pay gap is evident across all educational qualification levels in the field of engineering. Women with VET qualifications earn $60,000, which is $10,000 less than men. The gap narrows slightly among those with undergraduate STEM qualifications, with women earning $71,000 compared to men's $72,000. However, for women with postgraduate STEM qualifications, the gap widens significantly, with a median income of $88,000, which is $17,000 less than men. These disparities highlight the need to address gender inequities at all levels within the engineering field.

3.3. Computing and Information Systems

Interestingly, women in this field with VET qualifications earn slightly more than men, with a median income of $62,000 compared to men's $60,000. Among those with undergraduate STEM qualifications, women's median income is equal to that of men at $69,000. However, for women with postgraduate STEM qualifications, the gender pay gap widens again, with a median income of $95,000, which is $9,000 less than men. These fluctuations suggest a complex interplay of factors influencing gender pay disparities.

3.4. Science and Mathematics

In this field, women with VET qualifications earn $50,000, which is $10,000 less than men. The pay gap persists among those with undergraduate STEM qualifications, where women earn $65,000, which is $2,000 less than men. The gap remains consistent for women with postgraduate STEM qualifications, with a median income of $89,000, which is $10,000 less than men. The consistent gap across all qualification levels in this field reflects an ongoing challenge in achieving gender pay equity.

3.5. Additional evidence

Evidence presented in the above underscores the pervasive issue of gender pay disparity within STEM fields across different educational qualification levels. While there are instances where women's median income matches or even exceeds that of men, these instances are not consistent and do not negate the overall pattern of inequality. The data underscores the need for targeted efforts to address gender pay gaps in STEM, particularly in fields like engineering and science, and at higher qualification levels. Effective strategies for promoting pay equity may include raising awareness, advocating for fair policies, and fostering inclusive workplace cultures that value and reward the contributions of all individuals regardless of gender.

The issue of pay disparity is not limited to STEM. Across all industries, the national gender pay gap (based on full-time workers and base salary only) is 13% as of August 2023 (Commonwealth Government of Australia, 2023). Using the Workplace Gender Equality Agency (WGEA) Gender Pay Gap approach (which takes into consideration base salary, plus overtime, bonuses, additional payments, full-time and annualised part-time and casual workers), this difference is even more stark at 22.8% in November 2022.

$$Gender\ Pay\ Gap = \frac{(Average\ male\ remuneration - average\ female\ remuneration)}{Average\ male\ remuneration} \times 100 \quad (1)$$

With Australia's gender pay gap of 22.8%, for every $1 on average a man makes, women earn 77.2 cents. Over the course of a year, that difference adds up to $25,596. Alarmingly, the WGEA's latest Employer Census found that every industry in Australia has a gender pay gap in favour of men, even female-dominated industries such as education and healthcare. Additionally, latest data (2021-22) from the WGEA shows that every occupation and manager level in Australia has a gender pay gap in favour of men, with women on average earning anywhere between 73 cents to 95 cents of every $1 men on average earn.

Research by American Association of University Women found gender gaps are particularly high in some of the fastest-growing and highest-paid jobs of the future (i.e. technology/computer science and engineering) (American Association of University Women, 2022). Given the emerging prominence of data science in the United States of America (USA) (LinkedIn, 2021) and the fact that Industry 4.0 (Swinburne University of Technology, 2022) is largely embedded in global operations (particularly in developed countries), demand for workers in information technology will remain high. According to Hay's 2023/24 salary guide for Australia and New Zealand, the typical salary (excluding superannuation) of Queensland[5] workers in Data and Advanced Analytics is $100,000 or greater, whilst for Brisbane workers in Environmental Engineering, this is $120,000 or greater (Hays, 2023). Given these trends at the macro level and the ever increasing importance of STEM, it is imperative to bridge the equality gap for women in these fields.

According to the National STEM School Education Strategy 2016-2026, girls are more likely to miss out on the opportunities STEM-related occupations can offer as they are less likely to engage with STEM education (Department of Education, Skills and Employment, 2021). Overseas in the United Kingdom, behavioural analysis (Department for Education, 2020) on why female students are much less likely than their male counterparts to take A-levels (British Council, 2022) in certain STEM subjects has also been undertaken. The analysis found girls' expectations of success in STEM subjects relative to others appear to be lower than those of boys though their performance is no worse.

Australia is clearly not alone–gender disparity within STEM is a global, longstanding issue. Research from USA documenting the factors that perpetuate gender gaps in STEM has also been published (American Association of University Women, 2022). Table 2 denotes the main barriers that affect women in STEM in Australia (Women in STEM Ambassador, 2022).

Table 2. Barriers to women in STEM.

Barriers that affect Women in STEM Careers
Gender stereotypes and biased hiring practices
Limited workplace flexibility
Age-based discrimination
Workplace harassment
Gendered expectations of childcare
Limited support and encouragement for girls and women in STEM Education
Gender pay gap across all levels of employment

To strengthen the economic competitiveness of our country, we need to close the gender gap in STEM (European Institute for Gender Equality, 2022). In doing so, we can reduce skill shortages and increase the employment and productivity of women (i.e. develop our human capital). Moreover, gender diverse companies are

[5] Defined in this instance to be inclusive of Brisbane, Gold Coast and Sunshine Coast.

more likely to financially outperform their peers (McKinsey & Company, 2020).

Females in STEM encounter roadblocks across all stages of the STEM Career Progression Pipeline. To close the gap in STEM, we must give girls and women the skills and confidence to succeed in mathematics and science; improve STEM education and support for girls starting in early education and through kindergarten to grade 12; work to attract, recruit and retain women into STEM majors and fields in colleges and universities; and improve job hiring, retention and promotion pathways and intentionally inclusive cultures.

These recommended actions reflect this year's International Women's Day theme: 'Embrace Equity' (International Women's Day, 2023). In this instance, 'equity' recognises that each person has different circumstances, and allocates the exact resources and opportunities needed to reach an 'equal' outcome. For instance, a female Graduate Engineer is given the same Personal Protective Equipment (PPE) as her male counterparts for field work. Whilst this scenario demonstrates equality, it does not demonstrate equity. One-size-fits-all PPE is often too big for women. Equity is ensuring PPE comes in sizes that cater for women. Without equity, we will struggle to move the needle forward, and close the gender gap. Somewhat reassuringly, the Department of Industry, Science and Resources is currently undertaking a diversity in STEM review, with women in STEM being a focus of the project (Department of Industry, Science and Resources, 2023).

Despite current measures–e.g., strategies (Department of Industry, Science and Resources, 2019) and grants (Department of Industry, Science and Resources, 2021), more needs to be done, conjoined with more effective evidence of the impact of existing initiatives (McKinnon, 2022). For instance, an 'equal pay for equal work' system could be given a trial-run with measurable goals and objectives (Harvard Business Review, 2021). Implemented in 2018, this policy has been successful overseas in Iceland (regarded the most gender-equal country in the world) (World Economic Forum, 2021). To date, 91.2% of the gender gap has been closed in Iceland, compared to 77.8% for Australia (World Economic Forum, 2023). Although no country has yet achieved full gender parity, the top nine countries have closed at least 80% of their gender gaps. These proportions prove that we still have a long way to go. Globally, the outlook is less promising, with the year of expected parity being 2154 (or 131 years to close the gap) (World Economic Forum, 2023). Meanwhile, the 2023 Gender Inequality Index posits that at a one percent per annum rate change in the index, it will take 18.7 years to reach perfect equality in Australia (Per Capita, 2023).

Ultimately, greater representation of females in STEM is a critical step in the right direction for the ongoing journey to solve income disparity between males and females. Learnings and successes on breaking down the well documented barriers for women in STEM can help to inform the pathway forward for many industries.

4. Concluding Remarks

In conclusion, the intersections between gender inequality and STEM equity in Australia are profound. The struggle for gender parity within STEM fields highlights societal disparities that necessitate comprehensive strategies to bridge gaps and ensure equal opportunities. The pursuit of STEM's economic potential aligns with a need for inclusive growth, emphasising the importance of addressing gender disparities and fostering equity.

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Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

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