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Editorial: Addressing Gender Inequities in STEM through Interdisciplinary Perspectives

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ABSTRACT
In this editorial, the Guest Editors overview the papers contained within the Special Issue and discuss synergies between the presented keynotes and individual papers from the 5th biennial Network Gender & STEM Conference, 29–30 July 2021 at the University of Sydney [online]. The Special Issue showcases significant individual contributions from the 5 keynote addresses, 6 empirical studies and 2 case studies. Collectively, it highlights the amplified impact of an assemblage of interdisciplinary perspectives on the diverse issues associated with addressing gender inequities in STEM.

KEYWORDS
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Editorial: Addressing Gender Inequities in STEM through Interdisciplinary Perspectives

Gender disparities in particular fields of science, technology, engineering and mathematics (STEM) continue to fuel the concern of researchers concerned with gender equity, and professionals, employers, educators and policymakers who work in STEM fields. The 5th biennial conference of the international Network Gender & STEM focused on connecting policy and practice with research partnerships to educate and support STEM professionals of the future with the theme of 'STEM Education for the New Work Order: Policy, Practice and Partnerships' (29–30 July 2021 at the University of Sydney [online]; www.genderandSTEM.com). Since new interdisciplinary drivers are transforming work and education in response to social and environmental challenges and technological advancement, the Network asked: *What is the role of STEM for the new work order, and how can we engage and prepare all young people including girls and women?* As such, the conference aimed to deepen insights and shape action by integrating diverse knowledge perspectives and participants from the key stakeholder groups. Through this Special Issue, the Network aims to further stimulate new research and inquiry and formulate policy and practice that can promote the participation of girls and women (and boys and men) in STEM fields. By exploring research perspectives (*What do we know?*) and practice perspectives (*What can we do?*), readers are challenged to consider next steps through policy perspectives (*Where to from here?*).

Research Perspectives: What Do We Know?

Researchers have investigated gender disparities in STEM education and career pathways for decades, making significant contributions to our understanding of the complex issues associated with girls and women being sustained in versus opting out of particular STEM pathways. It was therefore very fitting that one of the conference keynotes was presented by Network Patron Distinguished Professor Jacquelynne Eccles, a leading developmental scientist who has made significant contributions to the field over the past 40 years. In her keynote address, "So what have we learned?", Eccles highlighted key learnings over this time, with a particular focus on the evolution of her Expectancy-Value Theory, to Situated Expectancy-Value Theory. She also called for researchers to apply a critical lens when conducting research on gender inequities in STEM, as gendered participation is very contingent on the definition of STEM that is applied. A summary of this keynote is included as the first paper in this Special Issue, including a link to the full recorded keynote address.

Following Distinguished Professor Eccles' keynote summary is the first empirical study in the Special Issue, which continues the theme of research contributions aimed at understanding gender disparities in mathematics over time. Rubach and colleagues conducted an extensive investigation into whether there is evidence of historical changes in gender differences in American high school students' mathematics competence beliefs over 40 years. Using six datasets, the authors found that mathematics competence beliefs were higher for boys compared to girls, and that this did not vary across datasets or over time. They also found that this gender difference was observed in all examined grade levels (grades 9–12) but varied for some racial/ethnic groups. As a result, the authors call for future research into young people's motivational beliefs in STEM to

consider how and to what extent gender *and* race/ethnicity intersections provide a more accurate understanding of the groups among whom gender differences exist.

The second empirical study of the Special Issue continued the focus on mathematics, as Toh and Watt explored whether there were gender differences in how parenthood affected mathematics career choices, and the potential role of traditional gender role beliefs in these relationships. This longitudinal study followed participants from secondary school to adulthood (mid 30s), to examine influences on changes in mathematics-related career aspirations during adolescence and until actual career in adulthood. Overall, men were more likely to aspire to and pursue mathematics-related careers, regardless of having children or not. The authors share positive findings regarding women in mathematics careers: that women who had children were pursuing mathematics-related careers to the degree that they had aspired to as adolescents, and women without children were pursuing *more* mathematics-related careers than they had aspired to as adolescents. While traditional gender role beliefs were more pronounced among men who had children compared to the other gender × parenthood groups, such beliefs did not influence the relationship between gender, parenthood, and mathematics-related careers.

In the third empirical paper, Graham and colleagues further delve into the role of gender biases in STEM, with a particular focus on preservice teachers' physiological arousal when confronting their implicit biases. The results from this pilot study suggest that participants experienced higher cognitive load when they attempted to associate "female" with "science" in comparison to "males" with "science", and that they experienced a pronounced stress response when receiving feedback on their implicit gender biases. While further research is needed with larger and more diverse samples, this study provides initial evidence of an innovative approach to investigating and potentially responding to STEM gender biases among preservice teachers, before they commence their careers as important socialisers of children's and adolescents' development in schools.

Practice Perspectives: What Can We Do?

A practice-oriented approach is also critical when responding to gender disparities in STEM education, aspirations, and careers. Sarah Chapman, recipient of the Barbara Cail STEM International Fellowship (2016) and experienced Australian secondary science teacher, provided a passionate keynote address, titled "The Power of Partnerships to Promote Engagement of Young People in STEM: International and Local Perspectives". In her address, Chapman shared her experiences and learnings from research and teaching fellowships, with a particular focus on using four key strategies to promote girls' engagement in STEM: effective messaging, girls-only opportunities, family involvement, and authentic connections. The keynote summary included in the Special Issue delves into these practices in detail, which should be of great interest to educators and researchers interested in interventions to address gender disparities in STEM. In another keynote with clear practical implications, Professor Mustafa F. Özbilgin presented on "The emergence of atypical leaders and their role in equality, diversity, and inclusion-led changes at work – towards a co-design approach". For STEM fields in which women are underrepresented, particularly in leadership roles, Professor Özbilgin's keynote summary provides

an insightful discussion on what atypical leaders, such as women in STEM, may experience and how they can be fostered to transform STEM fields to be more inclusive and equitable.

The remaining empirical papers in this Special Issue report on interventions that were designed to increase girls' STEM identities and engagement in STEM (Prieto-Rodriguez et al.; Giese et al.; Crowder & Whittle), support teachers to increase girls' achievement in STEM (Koh & Chapman), and support women's engagement in university mathematics (Kavatsyuk et al.).

The fourth empirical paper of the Special Issue reports on an outreach intervention that aimed to support secondary school girls' STEM identity formation, interest, and participation. Prieto-Rodriguez and colleagues adopted a problem-based activity approach, delivered with the support of female mentors across nine schools in Australia. Post-intervention focus groups with participants emphasised the importance of contextualising STEM learning to girls' lives, and that girls were cognisant of the societal influences that influenced their STEM interest and aspirations. The authors highlight the importance of leveraging problem-based learning to help girls understand the relevance of STEM, while supporting girls' STEM identity development through access to women working in STEM fields.

The fifth empirical paper of the Special Issue reports on a two-day interdisciplinary course on engineering careers in the water sector. In light of previous research on gender differences in self-efficacy, social belongingness and communal career goals in engineering, the empirical paper by Giese and colleagues research aimed to highlight the importance of effective interventions when attracting women to engineering. A promising result of their industry-designed intervention with high school students was that the intervention raised women's engineering self-efficacy and social belongingness and reduced stereotype threat levels. Engineering interest was unexpectedly not affected by the intervention, which may imply that stronger increases in self-efficacy and social belongingness are necessary to impact students' interest.

Self-efficacy was also a focus in Crowder and Whittle's case study on the design and implementation of an innovative four-day STEM camp for middle school girls from underserved communities in the United States. In their paper, they report on the impact of their STEM camp on girls' self-efficacy and attitudes towards STEM. Results highlight the importance of establishing community connections and implementing interventions designed to impact on girls' STEM interest, engagement, and self-efficacy, in addition to youth volunteers' STEM outreach activities in the community.

Next Koh and Chapman address the critical need to build teacher capacity in the design and development of instructionally sensitive, authentic assessments that possess the potential to promote engagement of girls in upper primary school STEM learning. Through their empirical paper, they report on a large design-based research study for building such capacity for promoting girls' STEM self-efficacy and interest in STEM. Participants included three Canadian grades 5 and 6 teachers and their students. Findings indicate that, despite their capacity to design assessment tasks with a real-world problem, teachers tended to focus on the solicitation of students' factual and procedural knowledge, lacked capacity to

promote students' integration of mathematics and sciences, and encountered some implementation challenges. Recommendations include prioritising sustained professional development that helps build teachers' capacity to design and implement high-quality authentic STEM assessments for girls.

The second case study in the Special Issue explores the role of the university classroom in supporting the development of a strong STEM identity in an introductory Calculus course. To generate evidence-based recommendations, Kavatsyuk and colleagues employed student-led research into how the course could become more inclusive. Next, they detail their evaluation of the impact of the course on students' confidence as learners and their intention to continue with STEM education. Implications extend from their understanding of activities designed to support university students' STEM identity development and include a set of concrete, evidence-based, and gender-inclusive instructional practices.

Policy Perspectives: Where to From Here?

Professor Sue Thomson was featured as the opening keynote speaker for the 2021 Network Gender & STEM Conference because of her dual research and policy roles. Thomson is the Deputy CEO (Research) for the Australian Council for Educational Research. Thomson analyses and reports on large-scale international and longitudinal studies with a focus on gender and socioeconomic equity. Her many publications include translational work aimed at impacting the outcomes of education and equity issues in Australia. Her research-informed Keynote was titled, "STEM Participation, Achievement and Beliefs". In it, she drew from contemporary large-scale international comparative datasets and reports to highlight how girls and women do not enrol in advanced mathematics, science, or ICT, or move into STEM-based careers, to the same extent as boys and men. Her keynote addressed three broad areas that may hold girls and women back: achievements, perceived abilities, and cultural beliefs.

Professor Ana Deletic also provided a call to action through her keynote "Women in Engineering in Academia: Are we there yet?". Deletic is Executive Dean of the Faculty of Engineering at Queensland University of Technology. An internationally engaged and respected researcher, Deletic has been researching in the field of urban water engineering for almost 30 years and is the most published researcher in the world on the topic of storm water management. In her Keynote address, Professor Deletic detailed the low participation of women in engineering as among the lowest of all the STEM professions. This is mirrored by the low participation of women in undergraduate and postgraduate engineering studies, and is particularly evident in the teaching and research staff of engineering faculties at universities across Australia. Through her address, Deletic outlined key issues and reasons for the low rates of women lecturers and researchers in her field and closed with proposed actions for overcoming barriers to greater participation.

A common thread of the conference Keynote addresses was that girls and women opt out of some STEM fields for a variety of reasons. At a policy level, there is a need for continued focus on initiatives that address gender inequities. As highlighted by Rubach and colleagues in their empirical paper, gender differences in mathematics self-concept have proven stubborn to shift, suggesting that strategies to address particular gender inequities in STEM have had limited impact to date. Toh and Watt's findings suggested that policies

promoting family-friendly initiatives can support women to choose and remain in mathematics-related careers. Therefore, policy innovation is urgently needed to address gender equity issues.

Concluding Comments

The Keynote summaries, empirical papers and case studies included in this Special Issue cover a diverse range of perspectives united in their aim to understand and respond to gender inequities in STEM. The research perspectives highlight advances in knowledge and understanding about the gender disparities in STEM that continue to exist. Key takeaways include the need to carefully define the domain of STEM being examined, particularly in specifying where gender differences exist; and the benefits of considering gender *and* race when investigating gender differences. While gendered beliefs and biases still exist, there is promising evidence of changes in these beliefs over time. Practitioners and researchers alike have provided a range of interventions, using innovative approaches with adolescents, teachers, and university students, in order to respond to the diverse issues that impact girls' and women's participation in STEM. The policy level recommendations offer provocations around possible macro-level supports to sustain girls and women in STEM. Overall, the collective contribution of the diverse perspectives in the Special Issue reflects the conference theme of 'STEM Education for the New Work Order: Policy, Practice and Partnerships', and highlights the importance of interdisciplinary approaches to address gender inequities in STEM.