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Guest Editorial for the Special Issue

"Gendered Pathways: Identifying Barriers and Building Bridges to STEM Education and Careers"

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Despite progress in gender equity in science, technology, engineering, and mathematics (STEM) over the past decade, girls and women still face many barriers when it comes to participating in STEM education and careers. The resulting "gendered pathways" become evident in enrolment, completion, and attrition rates. The 6th biennial conference of the Network Gender & STEM, which was hosted by Bernhard Ertl, therefore revolved around the question "Who comes, who stays, who goes, and why?" (July 21–23, 2022 at Universität der Bundeswehr München, Germany). As such, the conference aimed at bringing together key stakeholders including researchers, educators, policymakers, business and industry representatives, as well as the public to discuss the multifaceted influences towards, or away from, diverse STEM pathways across stages and settings.

With this special issue, we aim to further contribute to our understanding of where we still see gendered pathways in STEM. A particular focus on different STEM fields seems particularly important, as the most recent figures on the average proportion of female graduates in different STEM fields ranged from 23% in information and communication technologies to 54% in natural sciences, mathematics, and statistics across countries of the Organization for Economic Co-operation and Development (OECD, 2023). The second aim of the special issue is to identify which individual, social, and contextual factors act as either barriers or bridges to girls' and women's participation in STEM.

SPECIAL ISSUE: PART I

Following a theoretical paper, which offers a conceptual framework to gain a better understanding of the interlinked processes between micro- to macro-level influences in shaping male and female students' career aspirations and pathways, this edition includes three empirical papers based on large-scale survey data that investigate factors at different levels that contribute to girls and women turning towards or away from different STEM fields.

Following from her Keynote address, Ingrid Schoon argues that in order to gain a deeper understanding of and to effectively address persisting gender inequalities, it is essential to consider the dynamic interactions between individual-level processes, institutional factors, and social structures in a wider socio-historical context. Combining the situated expectancy-value theory with the motivational theory of lifespan development, socio-ecological models of human development, and the sociological life course theory, she introduces the INtegrated socio-ecological DEvelopmental Systems Approach (INDESA) as a useful integrative framework for studying gendered pathways. She further critically discusses that efforts aiming to address gender imbalances in career choices tend to focus on the characteristics of women that need to be "fixed", not men or the social structure of society at large. Lastly, she advocates for a more nuanced conceptualisation of gender and the consideration of intersecting social identities beyond a gender-only approach.

In the first empirical paper, Ralf Minor, Kathrin Leuze, and Ellen Winkler raise the question of whether there is a "STEM personality" and examine the relationship between students' personality traits and STEM career aspirations in German secondary education. Using data from the National Educational Panel Study (NEPS), their results suggest that high levels of openness increase the probability of holding engineering and technology aspirations among ninth grade girls and boys. While there was no other significant relationship between personality and STEM career aspirations among boys, girls with high levels of extraversion were more inclined to aspire to careers in engineering and technology, suggesting that traits such as sociability, talkativeness, and assertiveness may be beneficial for girls in developing gender-atypical career aspirations. With regard to their finding that conscientiousness was negatively related to girls' mathematics and science aspirations, the authors further discuss that since girls are generally more self-disciplined, industrious, and organized, as well as more inclined to aspire to non-STEM career paths, less conscientious girls are also less stereotypical, which might explain their preference for gender-atypical mathematics and science occupations.

The second empirical paper draws on survey data from the German sample of the Teaching and Learning International Survey (TALIS) Video Study. Focusing on the STEM field of mathematics, Kaley Lesperance, Jasmin Decristan, and Doris Holzberger investigate how student gender relates to self-concept, self-efficacy, and interest in secondary school lessons on quadratic equations, and whether students' perceptions of constructive support by their teachers moderate the relationship between gender and these motivational outcomes. While the authors found gender differences with regard to both competency-related outcomes, they did not find a significant effect of gender on interest, suggesting that persistent gender gaps may be due less to girls' lack of interest and more to beliefs about their abilities and competencies in mathematics. For

boys and girls alike, students' perceived instructional and social-emotional support by teachers each had a positive effect on interest, whereas only the first facet of perceived teacher support had positive effects on self-concept and self-efficacy. While it is positive that perceived constructive support has beneficial effects for students regardless of their gender, the authors discuss that their results may at the same time signify that even with teachers who provide clear feedback, helpful resources, and guidance, as well as who foster belongingness and emotional well-being in the classroom, girls still show lower levels of motivational outcomes in mathematics.

Shifting the focus away from school to a later stage in women's career, Anna-Katharina Stöcker and Astrid Schütz examine traditional gender role attitudes among STEM and non-STEM managers using data from the German Socio-Economic Panel (SOEP). Overall, the authors found more traditional attitudes among male than female managers. Considering that there is still a gender gap in management positions to the detriment of women, the authors discuss the potential negative effects of their finding with regard to gender equality and diversity in the workplace. At the same time, however, only among male managers was an older age related to more traditional gender role attitudes. When contrasting different occupational fields, interestingly, gender role attitudes were not more traditional among STEM than non-STEM managers. Rather, the authors' results indicate a small effect in the direction of less traditional gender role attitudes among STEM managers, which was substantiated when extending their sample to non-managers of different occupational fields. Moreover, the effect of working in STEM was larger for women, which, together with their results on male and female managers, the authors discuss in terms of selection (women with more traditional gender role attitudes may leave STEM fields or give up their careers before being promoted) and socialization (exposure to non-traditional attitudes in a non-traditional occupational field or position) processes.

SPECIAL ISSUE: PART II

Using a variety of methodological approaches—from large-scale quantitative survey data to experimental data and qualitative interview data—the empirical papers in this edition examine individual- and contextual-level factors that promote or hinder the initial interest as well as persistence of women in STEM fields that differ in terms of gender-related connotations and representations.

In the first paper, Isabelle Fiedler investigates to what extent gender differences in academic self-concepts vary across STEM fields with different gender compositions, and how students' academic self-concepts relate to their degree completion. Drawing on data from the National Educational Panel Study (NEPS), her results show that female students reported significantly lower academic self-concepts in STEM fields with either a low or high female representation. Moreover, she found that students' academic self-concepts were generally lower in STEM fields with a low proportion of female students, and that they positively predicted their graduation likelihood in these STEM fields more strongly than in those with a moderate or high proportion of female students—irrespective of students' gender. She discusses her findings with regard to field-specific cultures and climates.

In two experimental studies, Sören Traulsen and Lysann Zander examine whether STEM image videos featuring authentic female scientists—combined with framings of communal vs. agentic goal orientations—can increase students' domain-specific interest and perceived utility value. Whereas female students reported higher interest and utility value in the more female and communal connoted domain of biomedical engineering after watching the video, they reported lower interest in the rather male and agentic connoted domain of geodesy in comparison to male students. The framing of the respective domains as either affording agentic (i.e., importance of independent work or assertiveness) or communal (i.e., importance of collaborative work and connection to the research community) goals, however, did only have an effect in the domain of geodesy: Here, male students expressed higher interest in the agentic condition than female students. The authors discuss image videos as a means to get young individuals interested in STEM, taking into account field-specific differences in terms of their gendered connotations.

With a focus on the scientific landscape in Germany, Anina Mischau and Anna-Christin Ransiek examine the recruitment and support practices in a mathematical cluster of excellence. The results of their qualitative interview study illustrate how the recruitment and support practices of principal and associated investigators in the cluster are interwoven with gender stereotypes, thereby creating potential barriers for (prospective) female PhD and postdoctoral students in the STEM field of mathematics. Specifically, the authors found that both male and female "gatekeepers" ascribed different traits, motivation, and life circumstances to male and female mathematicians, which qualify them differently for a successful scientific career. The decision to pursue or continue such a career is therefore not interpreted as a structural problem, but rather an individual decision, as the authors discuss. Moreover, they found that internal recruitment is widely practiced and that—although it can in principle also benefit women who are already part of the scientific system and are considered qualified for the position—it tends to favor men. The gatekeepers' individual contribution to the (re)production of inequality-promoting structural or cultural conditions was barely reflected, but rather attributed to external factors. Regarding the support of PhD and postdoctoral students, the authors found mostly positive statements, but also some that indicated that male gatekeepers sometimes perceive mixed-gender supervision as more complicated or uncomfortable.

Overall, the research in this special issue covers a variety of disciplinary and theoretical perspectives on gendered pathways in STEM and is situated in a range of educational and professional contexts spanning different age groups and STEM fields. Pointing to factors from the individual level to those at the social and contextual levels, the contributions gathered here advance our knowledge about gendered barriers, but also resources that pave the ways to pursuing and persisting in different STEM fields. Key takeaways include the need for a more holistic view of gendered pathways—not only of the dynamic interaction between changing individuals in changing social environments and socio-historical contexts, but also intersecting social identities—as well as the need to differentiate between different STEM fields.

The 7th biennial conference of the Network, entitled "Future Directions in Theory, Research, Policy and Practice", will be hosted by Birgit Spinath and take place from July 18–24, 2024 at Universität Heidelberg, Germany. With the latest

employment projections showing that STEM occupations are expected to grow 10.8 percent by 2032 compared to 2.3 percent for non-STEM occupations (U.S. Bureau of Labor Statistics, 2023), it is increasingly important to develop insights into the various connected aspects influencing gendered educational and career choices in the direction of STEM. The conference therefore aims to inform theory and knowledge development as well as STEM practice and policymaking, and to exchange information about different approaches, methods, results, and starting points for interventions.

The conferences and resultant journal special issues are an initiative of the international Network "Gender & STEM: Educational and Occupational Pathways and Participation". Members include multidisciplinary researchers, scientists, policy workers, and educators who share the objectives of:

(i) gaining more insights into the various connected aspects of career choices and professional careers of girls/women (and boys/men) in the direction of STEM, and

(ii) detecting new approaches to actually improve the underrepresentation of girls/women in STEM.

For further details on the Network Gender & STEM, including details of previous biennial conferences and associated journal special issues, please refer to the Network's website: www.genderandSTEM.com.

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