Sciences,
Humanities,
Technology,
Engineering,
Mathematics
Education

Sciences, Humanities, Technology, Engineering, Mathematics Education:

Minoritized Women and Girls

By

Kalpana Mukunda Iyengar,
Howard Leslie Smith, and
Nadiah Sanabria Al-Gasem

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To my sister Hanna—my "limited edition" queen. Your one-of-a-kind attitude has been my compass, guiding me toward self-love, self-discovery, and a fearless sense of identity. You're powerful, brilliant, and delightfully chaotic—a perfect balance of "girl power" wrapped in glorious unpredictability. To my mamá, Silvia, who refused to let me settle for anything less than my best. You taught me that no barrier is too high to scale, and no challenge is too difficult. You also made sure I understood the beauty of empathy and perspective, always reminding me, "Cada cabeza es un mundo." Your wisdom and love are engraved in every fiber of my being. To my dad, Zaki, who ignited my perpetual curiosity and love for learning. Dad, you showed me the joy of fearless exploration of the unknown, the wonders of the learning process, and the unmatched value of education. Every concept explored is due to my inherited passion for discovery. To my husband, Michael - you are my champion. Thank you for enduring my late-night writing marathons, early morning coffee-fueled ramblings, and all the chaos in between. Now, at long last, you'll understand what ethnomathematics actually is. And yes - it is just as exciting as I said it would be.

Finally, I dedicate this book to all the girls who ever stepped into a STEM class, secretly hoping to be seen, recognized as valuable, or to feel capable. This volume is offered to encourage the girls who stared at a math formula and thought fearfully, "I can't—I'm a girl."

The authors of this book see you. We hear you. We are here to tell you that you are smart. You are powerful. You absolutely belong in the beautiful world of mathematics. Remember—without women and girls, mathematics would not be as advanced as it is today.

Dr. Nadiah Al-Gasem

This volume is an offering to 'NAVARATHNA', my mother, Vatsala Kadaba, who made me who I am today! I recognize my professors from my undergraduate studies in the sciences at Arakalagudu Varadarajulu Kanthamma College, India. Included in this dedication are my educators in graduate school, Dr. M.A. Yadugiri and Dr. Sarala Krishnamurthy. Because of their integration of mathematics, I wish to recognize Bharatanatyam dancers and their gurus (especially, Guru Bana Shastri Ramanath) worldwide. As the writings in this volume demonstrate, the dance infuses mathematical concepts, i.e., geometric shapes as it proffers Cultural Rhetorical Knowledge to deepen an appreciation and veneration for Bharata-centrism.

I must also make a public confession of being a proud mother of a daughter preparing for a STEM career. She exemplifies the amalgamation of STEM and the performing arts. Because of their indispensable support during my B.Sc. and master's degrees in India, I offer my sincere appreciation to my dear aunts, Nagarathna Mukunda, Geetha Srinivas, and Padma Nagendra. For their encouragement and validation, this book is also a humble gift to my friends both in India and America. I would like to remember Dr. Jayagowri Shivakumar, Prof. Krishna Galigali, Smt. Vasantha Kalbagal, Smt. Vidya Murthy, Prof Jeanette Pearce, Mrs. Sandra Ethridge, Dr. Lennie Irvin, Dr. Roxanne Henkin, Dr. Bekisizwe Ndimande, Dr. Marissa Muñoz, Mrs. Kalpana Rajagopal, Mrs. Ambika Natarajan, Mrs. Sruthi Halekote, and Mrs. Vijaya Gosala.

I dedicate this book to my family: Mukunda, my dutiful, long-suffering spouse (a clinical pharmacist), Mohan (a new veterinarian), and Gowri (a Bharatanatyam dancer and pre-med student). To my brother, Srinidhi Iyengar and my sisters-in-law, Kalyani Keshavan, Rekha Narayan, Poornima Narayan and Pushpa Vatsa for their presence in my life.

This anthology is also a humble offering to my mentor and collaborator, Dr. Smith. I believe I received divine grace for his support as we compiled this volume and our multiple publications.

Dr. Kalpana Mukunda Iyengar

This book is dedicated to all the educators, known and yet to be known, who struggle to create learning environments that encourage students, from all walks of life to be their best. This book is offered to further the understandings of pluralism and educational equity for all.

Dr Howard L. Smith

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Dr. Nadiah Sanabria Al-Gasem

As an Arab-Mexican, Dr. Al-Gasem was deeply influenced by two rich cultures with unique mathematical histories. In Mexico, the Mayans and Aztecs created one of the first calculators, the Nepohualtzintzin, and mastered the concept of duality. Meanwhile, the Arab world is known as the birthplace of equations, algebra, and the concept of zero. This mathematically rich heritage instilled in her a profound love for mathematics, earning her recognition as an honorary student and leading her to concentrate on math and science during high school.

In college, Dr. Al-Gasem pursued a career in engineering, elaborating on her desire to practice mathematics. However, loving and excelling in mathematics did not guarantee a successful career in the field. She endured gender bias at the hands of mathematical professors, engineering mentors, and even fellow male students. These social systemic barriers eventually led her to become one of the many women who left the field, adding to a troubling statistic. After a period of loss and confusion, a professor encouraged her to pursue a degree in education, igniting her passion for supporting girls and women in their paths to STEM.

This transformative experience fueled Dr. Al-Gasem's advocacy for girls in STEM. Her endeavors have been vast and varied: from integrating ethnomathematics into classrooms and after-school programs, to pioneering the first single-gender public school designed to build pathways for girls to pursue higher education in STEM fields, to managing state grants to establish STEAM and project-based learning campuses. Currently, as the Pactful project manager at the University of San Diego, she advocates for innovation for social good, using her platform to encourage girls to engage, create, and advocate for themselves.

This book is not merely an academic endeavor; it is a deeply personal project rooted in Dr. Al-Gasem's commitment to amplifying the voices of women. Her aim is to dissect the systemic barriers they face, and explore pathways for greater inclusion and equity. She recognizes that her positionality influences the questions she asks, the stories she prioritizes, and the solutions she proposes. Thus, she approaches this work with humility, openness, and a commitment to ongoing reflection.

Dr. Kalpana Mukunda Iyengar

Dr. Iyengar pursued her interests in chemistry, botany, and zoology by completing her Bachelor of Sciences at AVK College, Hassan, India. She broadened her education by completing a Master's of English in Linguistics and Commonwealth Literature at Bangalore University, India. She would later complete a second master's degree in English Education at Kutztown University in Pennsylvania. Through her doctoral program in Interdisciplinary Studies, her work with San Antonio Writing Project (Dr. Henkin), she acquired her preparation for pedagogy. Through her postdoctoral studies and the guidance of her mentor (Dr. Smith), she advanced her understanding of the importance and contributions of one's culture and heritage to psychological well-being, academic development, and success.

Dr. Iyengar is uniquely informed for the present volume. She is a woman born and raised in India. She was awarded degrees in two countries - sciences (India) and the humanities (India and the US.). She has performed the sacred *Bharatanatyam* dance. Iyengar teaches courses to pre-service teachers that emphasize the social contexts of STEM instruction. She was informed through her interaction with women from different cultural groups, and she became aware of the lack of representation of women and girls in the STEM disciplines. She listened to personal narratives describing a lack of access to mentorship, meager financial support, societal/cultural constraints, and irrational systemic barriers.

Dr. Iyengar is pleased that her children pursued careers in the sciences - her son, *Mohan* becoming a Veterinarian (DVM) and her daughter, *Gowri*, studying pre-med. While a clinical pharmacist, Mukunda Iyengar warned the family of the tendency for diasporic Indian families to over-emphasize on the sciences. Her position as a wife, mother, and scholar of multiliteracies, she is mindful of the values to be found in both the humanities and STEM fields. Her training in the humanities notwithstanding, Iyengar is aware of societal disparagement against those not pursuing the STEM disciplines or inclined toward the humanities.

Dr. Howard Leslie Smith

Dr. Smith is an African American professor of Language, Literacy, and Culture who understands the implications of cultural or gender exclusion in the educational trajectories of students.

Dr. Smith comes to the task of compiling the works in this volume as the concerned parent of an African American daughter. From her birth, Smith has observed the senseless obstructions she has had to navigate in order to pursue her interests in mathematics and sciences. Her textbooks had a dearth of female representation, especially in the STEM areas, effectively negating the possibility of role models for careers. He recognized the lack of attention to girls and women from minoritized communities necessitated efforts to increase their membership in the Science Technology Engineering Mathematics (STEM) pipeline.

After an unpleasant meeting between his daughter's vexatious mathematics teacher and her defensive principal, Smith worried that his daughter would become another discarded or jettisoned statistic who became discouraged and would shy away from anything technological. When the father told his bright, young African American daughter, she responded, "But, Dad. I love math!" With that, Smith entered the battle from female inclusion, especially for those who belonged to underserved-communities.

Through his scholarship on minoritized groups, Smith recognized that there has been negligible academic efforts to embrace women of color in the STEM areas, Smith and collaborators to this volume want to assist other educators in the creation anti-racist, gender-equitable pedagogies. The preparation for all pilots, doctors, engineers, and every profession begins with science, and mathematics taught in grammar school.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to Dr. Smith, not only for his role as my co-editor but also for being an exceptional mentor. I have been fortunate to receive mentorship, which goes beyond the classroom. He has instilled in me a profound understanding of the value of empathy, professionalism, and curiosity in both academic and personal growth. Dr. Smith's mentorship has shaped my approach to academia, helping me build a foundation to support me throughout my career.

I would also like to thank Dr. Iyengar, my fellow co-editor, whose unwavering dedication and meticulous attention to detail were instrumental in keeping us on track. Her ability to push us forward and ensure that we always strive for excellence have been invaluable. She is the driving force behind our success, and I am deeply grateful for her leadership. Thanks to my past mentors. Among the many, the list includes Dr. Judith Munter, Dr. Juliet Langman, Mrs. Sapien, Principal Victoria York, Dr. Sylvia Reyna. Their wisdom, guidance, and unwavering support have charted the course for my journey, leading me to incredible opportunities and experiences with this volume. I am indebted to all of them.

Finally, I am profoundly thankful to the community of the Young Women's Leadership Girls Academy, San Antonio, Texas. The faculty, from the principal to the teachers, have been a constant support- always willing to offer guidance and resources. I offer a special note of appreciation to the girls. I thank you for allowing me into your lives and sharing your world with me. Your openness and trust have made my experiences as a STEM educator truly unforgettable.

Dr. Nadiah Sanabria Al-Gasem

Much of my appreciation and love for culture, language, and literacy stems from my scholarly discussions with my mentor, Dr. Howard L. Smith. My passion for Indic-centric research was crystallized at the initiation of my residence as a postdoctoral fellow in the Bicultural Bilingual Department, UTSA. I express my gratitude for this unique opportunity to advance my research skills. I also wish to acknowledge the preparation given to me by the Department of Interdisciplinary Learning and Teaching at UTSA. I am indebted to Dr. Roxanne Henkin for her encouragement and support during my doctoral studies and for completing my dissertation. The current volume is one of the various opportunities that provided me with immense joy as I delve into topics related to Indic-centric culture, language, and literacy. I offer my heartfelt "pranam" to Dr. Smith for collaborating with me and trusting me with various book chapters in this volume and multiple scholarly articles beyond the present text. My sincere appreciation to Dr. Al-Gasem for her willingness to collaborate and co-write chapters.

Dr. Kalpana Mukunda Iyengar

I wish to acknowledge all the girls who have persevered in the STEM subjects, especially those from underserved communities. My heartfelt appreciation to all the STEM educators, who made a space for future generations in STEM vocations. I want to express my appreciation to all the professional women with whom we spoke, regarding their instructional experiences and how they navigated the obstacles encountered along the way to their professional victories. I feel it especially appropriate to acknowledge, perhaps, my biggest catalyst for collaborating on this volume - my daughter. After a skirmish with a high school mathematics teacher, I told my daughter I was afraid the bad experience would discourage her advancement. She looked at me shocked and said, "but dad, I love math. I'm not going to let this teacher stop me!" Here's to all the girls who won't let one bad apple stop their objectives and goals.

Dr. Howard Leslie Smith

INTRODUCTION

DR. HOWARD LESLIE SMITH, DR. KALPANA MUKUNDA IYENGAR AND DR. NADIAH SANABRIA AL-GASEM

Statement of Urgency

The Science Technology Engineering Mathematics (STEM) fields urgently need an increase in their numbers in order to address the divergent exigencies of the global society. While there have been efforts for general recruitment, there is a potential source of more recruits that has been sorely ignored. The main thesis of the present volume is a concerted effort to champion the female perspective in discussion around STEM instruction. The authors in the various chapters discuss the social positionality of girls (i.e., women) in STEM vocations, promising pedagogies, programmatic challenges, and remedies. The chapters in this volume discuss their participation, women and girls represent 51% of the world's population, but have been excluded from opportunities that highlight their participation and contributions (theoretical and applied). An even more expansive trove of potential candidates lies in the communities of color, i.e., under-served cultural communities. Rossiter (1993) expatiates on the historical extent of the problem:

> Recent work has brought to light so many cases, historical and contemporary, of women scientists who have been ignored, denied credit or otherwise dropped from sight that a sex-linked phenomenon seems to exist, as has been documented to be the case in other fields, such as medicine, art history, and literary criticism (p. 325).

Societies that have normalized the exclusion of girls and women from education or scholarship exacerbate the problem (UNICEF, 2020). Lincoln and colleagues explain the treatment of women (which concomitantly includes girls,) in the STEM fields. “Historically, male bias and misogyny have diminished or ignored the accomplishments of women, while exalting the achievements of men (Lincoln, et al, 2012, p. 307).” Rossiter (1993) further expatiates on the historicity of the practice:

> [T]his systematic bias in scientific information and recognition practices fits the second half of Matthew 13:12 in the Bible…[I]t is suggested that sociologists of science and knowledge [add] the 'Matilda Effect', named for the American suffragist and feminist critic Matilda J. Gage of New York, who in the late nineteenth century both experienced and articulated this phenomenon (p. 325).

The condemnable professional practice of denying women recognition or remuneration for their discoveries is still practiced to the present day. Despite their contributions in the 20th and 21st Centuries, inventors such as Valerie Thomas for 3D movies, Sharley Ann Jackson for fiber optics, and landscape architect Isabel Castilla for her eco-friendly transformation of public spaces [cf. Dallas, Texas] This misogynistic tradition is all-pervasive in the STEM areas (e.g., Patel, et al. 2021; Rajkó, et al., 2023). To make matters worse, the practice is documented across countries (e.g., Fiorentin et al., 2022); Văcărescu, 2023; Yakovenko, et al., 2021). In all countries, the victories of women in the science and mathematical fields have been riddled with instances of appropriation (e.i., ideas, patents) at the hands of their husbands and male partners (Friedmann & Efrat-Treister, 2023) and other forms of male privilege (Bray, 2007). Furthermore, women have been dispossessed of intellectual property by their male colleagues, who take credit for the (female) partners' ideas. The effect of the stifling of women's participation is that it repressed and erased role models that would have encouraged the interest (and possible recruitment) of women in the STEM fields. Moreover, by denying women recognition, they have been unjustly excluded from the recognition and commendations they deserved. Furthermore, countless women have been unremunerated through men

Inequitable treatment, e.g., exclusion from advanced mathematics and science classes and towards women in the STEM fields originate from socially constructed norms that ultimately, inhibit and limit many women. McKinnon & O'Connell (2020) conducted research with over 300 participants and found that within their study "the results showed women who publicly communicate their work are likely to be stereotyped as 'bitchy', 'bossy', and 'emotional'—often by their own gender'' (2020, p.160). As the prior discussion indicates, research (i.a., Eaton, et al., 2020; McKinnon & O'Connell, 2020; Smeding, 2012) documents that women themselves often internalize stereotypes that inhibit their advancement in STEM.

Systemic Barriers and Biases

There are three critical sources of obstacles - (1) those generated within the school system (e.g., excessive standardized test preparation, myopic Anglo-centric curriculum and staff), (2) extrinsic social anomalies (e.g., misogyny, gender inequality), and finally, (3) the intrinsic social-psychological level (e.g.., self-efficacy, "Girls can't do that," "But you're a girl!"). To address these, and other, inequalities, innovative interventions have been developed, often existing outside of traditional classroom settings.

At the school level, one potential remedy would be rebuilding the curriculum with the perspective of supporting every student in class, irrespective of their gender. This transformation re-centers pedagogy so that it no longer takes the male child as the cynosure of pedagogy. It requires an appreciation and validation of multiple forms of representation and epistemology. To develop critical thinking and problem-solving, skills with all students, we must seek strategic approaches that have been proven successful in supporting boys and girls in the STEM areas (e.g., Project Based Learning [cf., Almulla, 2020; Sumarni & Kadarwati, 2020]; Small group instruction [cf., Bonesrønning, 2022; Attard & Holmes 2022]. In their research Martínez- Blancas et al., (2023) discuss interstitial identities (i.e., women from minoritized communities). And the importance of addressing inequities emanating from gender and ethnic/racial biases:

> Little progress in promoting diversity, equity, and inclusion can be made without first accounting for the multiplicative effects of overlapping identities. Gender bias impacts all women, but especially those whose gender intersects with other identities that are often discriminated against, such as race and ethnicity, socioeconomic status… (p.7)

Research documents that girls continue to be underserved in schooling (Bergstrom & Ozler, 2023; Locke & Grooms, 2024; Shin, et al., 2023; Simon, et al., 2021). For that reason, more exploration is needed to identify strategies that are particularly effective in addressing their educational needs and increasing the number of women in the STEM pipeline. We argue that if pedagogies were to become more thematically inclusive, there would be an increase in the STEM initiatives across genders. If girls were encouraged and supported in the studies in the STEM areas, there would be a corresponding increase in the numbers of professional women in under-staffed and under-represented fields (e.g., aeronautics, engineering, medicine). The United States Equal Employment Opportunity Commission published a distribution of women in the STEM fields, Table 2 represents the percentage of women in STEM based on race and origin.

Table 2: Race and National Origin for Women in STEM

Race/National Origin	Women	Men	Total	% Women
African American/Black	14,066	19,256	33,322	42.2%
American Indian/Alaska Native	932	1,856	2,788	33.4%
Asian	9,423	19,926	29,349	32.1%
Hawaiian/Pacific Islander	268	697	965	27.8%
White	63,710	169,030	232,740	27.4%
More than one race	1,910	3,956	5,866	32.6%
Hispanic/Latinx	6,198	14,139	20,337	30.5%
Total	**96,507**	**228,860**	**325,367**	29.7%

Source: "Special Topics: Annual Report on Women in STEM," by U.S. Equal Employment Opportunity Commission, n.d. (https://www.eeoc.gov/special-topics-annual-report-women-stem).

According to published demographics, the percentage of women from minority communities *in the aggregate,* represent less than 20% of the professionals in the STEM fields. The glaring difference in female representation indicates the need for greater attention on strategies to attract, retain, and sustain girls from marginalized cultures into the STEM areas during their formative years in schooling.

For that reason, the contributions to this volume focus on girls and (college) women from marginalized/minoritized groups. The book also provides a guide to educators supporting girls and women in their pursuit of STEM careers (e.g., engineering [aeronautics], mathematics [computations], medicine [epidemiology], oceanography [Marine Life]).

The activities and findings in this book will scaffold educators as they create academic experiences for girls in the SHTEM areas (Science Humanities Technology Engineering Maths); that is, the use of pedagogies that acknowledge the unique perspectives and challenges of the female gender in school and society. In addition to more traditional approaches of STEM, they will be given opportunities to explore natural and social science and mathematics, science fiction writing, and the biographies of women who made contributions to mathematics/science, society, and the world (e.g., explorers, inventors, pioneers, practitioners) embedding the humanities within the scientific and mathematics content. In recognition of our vibrant,

multilingual society, contributions that privilege or explore biliteracy/multilingual Language Arts are included.

Outline of the Book

The book is divided into three sections. **In the first section,** the book provides theoretical context surrounding the SHTEM field and minority women within SHTEM fields. The chapter on *Background and Social Global Context* explores many of the systematic (e.g., exclusion from pivotal decision-making) and systemic barriers (i.e., multilevel, permeant) that limit the involvement of girls in math and science instruction. The impediments that girls confront in math and science study re-emerge as barriers to women in the STEM fields (Kuchynka, et al., 2022; Prieto-Rodriguez, et al., 2020). The problem is even more grave when the situation of marginalized or minoritized groups is factored in. In many communities, there are hierarchies which grant or deny privileges to members of constituent groups (e.g., cultural, economic, racial, religious, social). There are social privileges and penalties for membership in any group. The second chapter in this section on *Math as Social Construct: Ethnomathematics in Education* explores the role of Ethnomathematics for instruction. More specifically, it explores how this epistemological perspective can be leveraged to provide meaningful and engaging learning experiences for students. Using the construct of Ethnomathematics, as described below, educators are positioned to enhance instruction for girls i.e., a traditionally marginalized group, and emphasize culturally-constructed mathematical concepts as a key to achieving greater equity in mathematics education.

The second section of the book focuses on pedagogical aspects, and provides chapters focusing on STEM education practices. In the *Multicultural Children's Literature to Disrupt Myths and Misogyny Against Women from Marginalized Communities in STEM Fields*, Drs. Smith and Iyengar discuss literacy strategy that incorporates authentic Multicultural Children's Literature (MCCL). This instructional approach leverages the intentional selection of illustrated children's literature that foregrounds the contributions of minoritized women in the areas of Science Humanities Technology Engineering Mathematics (SHTEM). Through the discussion and activities, the authors interrogate the negligible and trivialized representation of female characters from minoritized communities in MCCL, especially as it relates to the STEM pipeline. To remedy the paucity of characters framed as aspirational or contributors to the advancement of STEM pipelines, as students are scaffolded through reflection, dialogic conferencing, and "situational

problematization" (i.e., a critical approach), students learn to disrupt oppressive and biased marginalization of women beyond a Eurocentric perspective. To stimulate critical thinking or *Higher Order Thinking Skills* (HOTS), the *Critical Reader Response* (CRR) framework, as the co-authors present, advances the language arts through Bloom's Taxonomy. The suggested lesson cycle, through gender-affirming MCCL, is a model to scaffold the development of a critical lens in LA.

In the chapter, *Bharatanatyam: Sacred Indian Dance and Mathematics Connections*, Dr. Iyengar explores the connection between mathematics (i.e., geometry) and an Indic-centric dance called *Bharatanatyam*. Through the dance, performers engage in systematized, strategically schematized movements. While appreciated for its aesthetic value because the various dance choreographies rely upon semiotics, kinesics, and aesthetic accouterments (e.g., jewelry, costuming, make-up), the underlying skill set is mathematical - geometric patterns and shapes. Twenty-five diasporic school-aged female students met for dance study in four different US-based dance schools in the Southwest were the data source for this study. They were regionally divergent, which was evidenced in their Indic cultural diversity, heritage language, and varying traditions. Data collection was a two-stage process. They were asked to respond in an essay to a three-item questionnaire on the theme of dance and mathematics. During the member check the formal interviews, young dancers were asked about what they wrote regarding math learning and connections between the two disciplines. The analysis revealed the concomitant relationship the school-aged dancers recognized between the sacred Indian dance and mathematics. Though often ignored, data analysis revealed that the young dancers perceived various aspects of mathematics (e.g., algebra, calculus, geometry) in their *habitus t*hrough their participation in *Bharatanatyam* dance. This argues for the inclusion of the humanities to support development in the STEM fields, i.e., STEM, becomes SHTEM. Mathematics is embedded, organically in the humanities, especially the arts (e.g., dance, music, painting) (Colucci, et al., 2019; DeFretias & Sinclair, 2014).

The chapter co-written by Drs. Smith and Iyengar entitled, *Critical Reader Response through Multicultural Children's Literature on Minoritized Women in SHTEM*, describes a series of Language Arts (LA) activities. The coauthors advance that the discursive (i.e., visual and textual) messages contained in pedagogical tools like children's literature may promote positive messages about women and stimulate reflective discussion and literacy activities. To facilitate the selection process of MCCL, which affirmed the SHTEM contributions of women from marginalized communities, the co-authors developed a table to taxonomize the significant elements of the

literature, i.e., MCCL. The lesson cycle is rooted in authentic MCCL that highlights women from minoritized communities and the STEM areas. The objective of the lesson cycle is to develop critical thinking and reflection among children. The co-authors argue that transformation occurs as educators de-center LA from their traditional, white-centric approaches. In lieu of male/Ameri-/Eurocentric lessons, educators can utilize pedagogies that foreground women from minoritized communities. The incorporation of authentic MCCL (especially illustrated stories featuring pioneering women) in literacy instruction allows learners to discover ignored trailblazers that may inspire youth, i.e., girls, to enter the STEM pipeline. The coauthors advance that the discursive (i.e., visual and textual) messages contained in pedagogical tools like children's literature may promote positive messages about women and stimulate reflective discussion and literacy activities.

In the final section, the book focuses on programmatic issues of females in SHTEM. This chapter, written by Dr. Al-Gasem, describes the development of a Girls' Academy (GA) within a public school district. It is written from the perspective of a mathematics classroom teacher. The creation of a single-gender school was unique because it was the first in the city, to serve low-economic families of minority population. Moreover, the academy was unique in its focus on leadership skills (e.g., individual determination, public speaking, community engagement). The underlying belief was that girls who developed their personal voice and leadership skills could leverage them into successful collegiate experiences.

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SECTION 1

CONTEXT

CHAPTER 1

BACKGROUND AND SOCIAL-GLOBAL CONTEXT: INTERSTITIAL SITUATEDNESS OF MINORITIZED WOMEN IN STEM AND SOCIETY

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This chapter explores many of the systematic (e.g., exclusion from pivotal decision-making) and systemic barriers (i.e., multilevel, permeant) that limit the involvement of girls in math and science instruction. The impediments that girls confront in math and science study re-emerge as barriers to women in the STEM fields (Kuchynka, et al., 2022; Prieto-Rodriguez, et al., 2020). The problem is even more grave when the situation of marginalized or minoritized groups is factored in.

In many communities, there are hierarchies which grant or deny privileges to members of constituent groups (e.g., cultural, economic, racial, religious, social). There are social privileges and penalties for membership in any group.

A review of historic, worldwide events reveals efforts (both individual and societal) for discrimination against women (cf. Cropley, 2020; Marçal, 2021). The anomalies uncovered do not remain confined or limited to grown women but become obstacles for schoolgirls. Upon reviewing the placement of women within the context of science, Rutherford (2020) finds that science is gendered. She was referring to "a set of processes whereby the ideas, theories, practices" (p. 21). Moreover, through their research, other scholars (e.g., Avolio et al., 2020; Garcia-Holgado, et al., 2023; Sebastián-Tirado, et al., 2023) advance that in all Science Technology Engineering Mathematics (STEM) related areas, the circumstances for women are equally dismal. According to Makarem and Wang (2020), "STEM women continue to face a myriad of challenges in a predominantly masculine environment (gendered organizational culture, gender-based stereotypes, struggle with work-life balance, and lack of mentors" (p.91).

The challenge of increasing the participation of girls from minoritized communities in STEM, necessitates a multifaceted approach given the amalgamated biological and social characteristics of the focal participants. Upon review of published studies, it can be said that researchers have identified interrelated concepts and core issues that appear to mediate the engagement of women and girls into the STEM areas (i.e., pipeline, vocations).

There is an urgent need for a greater number of girls and women to staff the STEM workforce (Fry et al., 2021; Kricorian, et al., 2020). Despite encouraging moments/spaces of enlightenment, women and girls continue to be subjected to marginalization. At the same time, many of the activities with a mathematical or science foundation (e.g., rising bread dough, artistic designs, geometric shapes of clothing, or dance) that are ascribed to women are trivialized or undervalued as contributors to cognitive development. As students and scholars explore the STEM areas, they must engage in reading (e.g., formulae, notes) as well as writing (e.g., reports, findings). Contemporary research argues for the recognition of valuable skills beyond formal traditional. It can be said that women have made inroads in the Science Technology Engineering Mathematics (STEM) fields. However, there continues to be a pressing need for human infusion into the STEM pipeline, specifically the increased respectful inclusion, equitable participation, and value-added recognition. Women's contributions run the gamut from daily applications (e.g., dishwasher, quotidian activities) to theoretical scholarship. (e.g., Katherine Johnson who calculated the trajectory for NASA's moon landing). Exacerbating the calamitous situation women in general are the disparagements experienced by women from minoritized communities (e.g., African American, Asian, Asian Indian, Latinx).

The statistics on exclusion become even more grim when the absence of women from minoritized cultures are factored in (Lathifa, 2023; O'Brien, et al., 2020). While there have been efforts to increase the representation of minoritized women, disparities and exclusions against women continue to plague society. Areas of needed growth include the financial sector (cf., Catenaccio, et al., 2022), the field of education (cf., Bradley, 2000), religious leadership (cf., Melania et al., 2021), medical policies and practices (cf. Bolin & Rolfes-Haase, 2023. The inequities exist across the age-spectrum, i.e., from adult women to school girls.

Researchers who explore this under-representation have identified psychological and social reasons that do not emerge from a lack of mental capacity nor initial interest in the subject matter (Epstein, 2022). Rutherford (2020) conducted an historical analysis of the representation of women from the mid-century (i.e., 1970's). Her findings indicated an under-representation of women in the sciences. These results aligned with current (i.e., 21st

century) studies. For example, Nguyen, et al., (2012), (citing Leaper, et al., 2012) advance that:

> [A]dolescent girls sometimes perceived pressure to conform to gender norms from their parents; this is consistent with studies finding that parents endorse stereotypes related to gender and STEM, which in turn are related to less recognition and lower perceptions of their daughters' STEM abilities (p.1442).

Beliefs and attitudes regarding genderized vocations'' are engendered through socialization. The normalization of behaviors and expectations contributes to the reticence many girls feel toward pursuing STEM careers.

Additionally, Bessie Blount (Bellis, n.d.) discusses several restricting behaviors and unsubstantiated beliefs (ant-SREM) that are prevalent in the socialization of girls. Her encyclopedic review discusses the stakeholders and the effects on girls:

> Leaper and Brown (2012) found that adolescent girls sometimes perceived pressure to conform to gender norms from their parents; this is consistent with studies finding that parents endorse stereotypes related to gender and STEM, which in turn are related to less recognition and lower perceptions of their daughters' STEM abilities (Eccles, 1994; Simpkins et al., 2015; Tenenbaum & Leaper, 2003; Yee & Eccles, 1988). Similarly, a handful of research studies also observed that STEM teachers tend to hold gender-biased beliefs related to STEM ability that advantage boys and result in them under-rating girls' performance (Carlone et al., 2014; Fennema et al., 1990; Shumow & Schmidt, 2013); other studies find that girls report (somewhat infrequently) experiencing academic sexism, gender bias, or sexual harassment from STEM instructors (Leaper & Brown, 2008; Leaper & Starr, 2019; Patall et al., 2018). Finally, STEM classmates and peers can also stand out for reinforcing the gender system, as young women report experiencing gender bias from this group of individuals, including negative comments about their ability (Foor et al., 2013; Leaper & Starr, 2019; Robnett, 2016). Similar to the research on encouragement for girls in STEM, research implicates both women and men as potential sources of bias and exclusion. Yet the literature points to particularly pronounced experiences of gender bias from young men in their STEM classes, including taking over labs and experiments, as well as ignoring or undermining young women by questioning their STEM ability (Foor et al., 2013; Guzzetti & Williams, 1996; Hennessy Elliott, 2020; Tonso, 2006; Wieselmann et al., 2020) (p. 685).

In sum, at all levels, (e.g., familial, social, professional) girls confront discouragement for involvement in the STEM areas.

These assertions are echoed in countless studies (e.g., Buse, 2018; Ertl, et al., 2017; Koch, et al., 2023; Malhotra, 2018). Concomitant with

oppressive social beliefs that discourage school-aged girls from the STEM pipeline, research reveals there are additional curricular factors contributing to the dearth in representation (i.e., membership and marketing) of women's participation. Teachers are not irreproachable on matters of gender-biased beliefs related to girls' STEM (Nguyen, et al., (2012), (citing Leaper, et al., 2012). Within this volume, the reader will find "promising practices" to transform their thinking and teaching about girls from minoritized groups and STEM education.

This "academic sexism" (social inequity) within the STEM areas, appears to have fossilized into an amalgamation of unenlightened opinions, irrational beliefs, and unfounded phobias limiting women from full participation and recognition in the STEM areas (cf., Casad, et al., 2021; Whitcomb & Singh, 2021). The problem is multi-faceted and pervasive. The oppression may be unwitting or intentional (Agarwal, 2020; Möller, et al., 2024; Nordell, 2021). The findings on the lack of female representation within the STEM related fields devastate society through misinformation, myths, misogynistic norms. Regretfully, this anomaly is not confined to the ranks of adult women, but permeates the age levels of all females, i.e., girls to women (American Psychological Association, 2016, November 22; www.adl.org, 2015) and all age-groups (Rogers, et al., 2021; Siani, et al., 2018).

Historical Review of Gender and Racially-driven Obstacles

Even those girls who are successful in academics may not be offered the same opportunities as boys (e.g., internships, mentorship, sponsored travel) (Copur-Gencturk, et al., 2020; González-Pérez, et al., 2020). The encouragement to explore the STEM fields that girls (i.e., future scholars) would receive is further doused from additional microinsults against women in the field. Even as they make important contributions (i.e., intellectual and applied), women from minoritized communities are still judged inferior and or ignored. Despite whatever preparation they may possess, they remain *unsung sheroes.* Even with societal advancements, this historic quote rings true today:

> In the 19th century…[m]any men…, including doctors, believed that a woman's skull (and therefore brain) was 10% percent smaller than a man's on average and believed as such that a woman – especially a Black woman – could never compete with a man intellectually. [Women doctors, especially those from minority groups, were] subjected to intense sexism as well as racism throughout [their] personal and professional life. Basic day-to-day job tasks that were easy for white male doctors, like getting prescriptions

> filled or getting traction for [their] medical opinions and publications, were much more challenging for [them]. Some even joked cruelly that the MD after [their] name stood not for medical doctor but for "Mule Driver" (Scheiber, 2022, para.3).

Throughout recorded history, women's sortie into the STEM professions has been problematic. Beyond the exigencies of their profession (e.g., medical), women from minoritized communities who enter the STEM fields face man-made obstacles that discourage or obstruct their success and recognition.

The following sections illustrate the multiple ways that women from minority communities were compelled to confront socially constructed challenges in an effort to prosper within the STEM fields. Gender bias and racial discrimination combine to create a toxic barrier to hinder their participation.

Traditions that Encumber Participation. Even those girls who are successful in academics, may not be offered the same opportunities as boys (e.g., internships, mentorship, sponsored travel) (Copur-Gencturk, et al., 2020; González-Pérez, et al., 2020). An additional obstacle against equitable participation (e.g., content areas, extra-mural scholastic activities) include cultural "norms" that constrain or impede girls' involvement in funded activities (i.e., *Girls should not be doing those things!*). In a similar vein, there are families, of diverse economic means, who are disinclined to invest in the education of the daughters of the family. The belief is that girls should become subservient stay-at-home wives and leave professional careers to the men and husbands. This circumscribed gender-based belief system metastasizes into needless restrictions and offenses against women. These peculiarities include financial inequities (e.g., salary), various forms of social inequality (e.g., reduced career opportunities), and misogynistic discrimination (e.g., leadership positions)

Gender-based Discrimination. A review of historic, worldwide events reveals efforts-both individual and societal-to discriminate against women (cf Bloodhart et al., 2020) and even more so women from communities of color (cf., Castro & Collins, 2021). Upon reviewing the positionality of women within the context of science, Rutherford (2020) argues that science is gendered. She described the conditions as "a set of processes whereby the ideas, theories, practices, epistemic values, and institutions of science become masculinized and feminized" (p. 2). Despite initiatives for social change, the startling discrepancies continue to emerge (e.g., Butler-Barnes, et al., 2021); Campbell-Montalvo, et al., 2022; Domingo, et al., 2022; Yadav, et al., 2020).

Cloaking Women's Talent. Countless inventions and discoveries by women have been hidden from general purview, i.e., public knowledge.

Copyright law and registered patents not-with-standing, women throughout history have been victimized and defrauded by plagiarism and various forms of misogynistic intellectual piracy. A cursory or partial list of women contributors who were victimized through denial of due credit is extensive. Such a list includes Empress Leizu in China, who discovered silk threads in 2640 BC. Another example is the Indian American chemist, Sumitra Basu Mitra who, in 1978, designed an innovative type of dental filling using nanoparticles, an emerging technology. Exacerbating the victimization through imposed anonymity, Mitra holds almost one hundred patents in nano composites and dental adhesives.

Ostracism, Piracy, and Plagiarism. The obstacles and injustices that girls confront persist and prevail into adulthood. The oppression of women through exclusion and arrogation of their talents has occurred within countless partnerships - both professional and intimate (i.e., romantic). While acknowledging the glacial improvements in public policy and social activism (e.g., *Lilly Ledbetter Fair Pay Act of 2009, Title IX, Me Too Movement*), male bias and misogyny continues to diminish and ignore the accomplishments of women of all ethnic communities in the STEM fields (Whitcomb, & Singh, 2021). Many times, an attempt to lionize an ostensible male achievement has cloaked a veridical accomplishment of a woman. Instances of appropriation of their ideas by husbands and male partners, acts of socially-normed exclusion (cf., Friedmann & Efrat-Treister, 2023; Morales & Marcén, 2024) diminish female contributions. If misogynistic conditions and other acts of hegemony are to be eradicated, further remediative measures must be enacted to affirm the efforts of women, especially those from minoritized, ethnic communities (i.e., African-American, Asian, Asian Indian, Latinx). The present volume is an effort to disrupt the egregious treatment of minoritized women in STEM and society.

Historical Exemplars: Ramifications of Interstitial Situatedness

A woman/girl from a marginalized culture embodies interstitial characteristics e.g., ethnicity, gender, social class. As such, they have a unique positionality in America. They are affixed to the behaviors, traditions, and worldviews of their cultural community. Indelible and synchronously, they belong to a gendered community, due to biological distinctions. That is, they belong to an underserved community, which increases the likelihood of exclusion from recognition. From the vast catalog of excluded minoritized women (and their contributions) to the STEM fields (Lawner, et al., 2019; O'Brien, et al., 2020; Nguyen & Riegle-Crumb, 2021; Nguyen & Ryan, 2008). We selected

examples from a copious list documenting theft of women's intellectual property, acts of financial piracy, gender and racially-driven invalidations, plagiarism, and copyright infringement. The aforementioned ethics violations are often labeled *micro-aggressions* or *micro-insults* (cf. Branlat, 2023; Halvorson & Vianden, 2023). The following pioneers discussed below were selected at random and represent the gamut of women scientists who were not well-served within the STEM professions.

We encounter the history of chemist Alice Ball. In 1915, who devised a procedure to reconstitute a lifesaving oil from a medicinal plant (*Chaulmoogra*) into an injectable, water-soluble solution to treat leprosy. Due to her death shortly after the discovery, Ball could not publish her findings. It was her graduate study advisor, Dr. Arthur L. Dean, who took credit for Ball's medicinal innovation. Brown (2012) details the intellectual piracy cloaking Ball's contributions.

> Her name is not mentioned in any of Dean's published works on the chaulmoogra extract, while the name "the Dean method" is appended to the technique … Paul Wermager, in 2004, quoted a 1921 newspaper interview with Dean, in which he emphasized the importance of the work of his predecessors in the development of the extract. Despite this, according to Wermager, the *Paradise of the Pacific* report goes on to mention Hollmann and other colleagues, but not Ball (p. 23).

Incessant narratives in which women are denied recognition for their intellectual efforts, similar to Ball (irrespective of the impact on), are as redundant as they are egregious.

The mistreatment of women of STEM from minoritized communities has continued into the modern era. The offenses against women and their work are pervasive, cunning, historic, and (lamentably) contemporary (cf., Butcher et al., 2020; Smith et al., 2023). A notable and valuable contribution to the STEM areas, especially to medical care, came from Ann Tsukamoto. In 1991, among her other discoveries, she co-patented a process that allowed the human stem cell to be isolated. This would have benefits for breast cancer treatments.

A further example of forced anonymity is found in the treatment of *Colored Computers* of the National Aeronautics and Space Administration (NASA). Individuals who were hired to perform complex mathematical computations were called "computers" until the late 1960's. Katherine Johnson was hired because, in the words of her colleague, "she [could] handle any numbers you give her." In the case of NASA during the 1960's, African American "computers" were segregated from their white counterparts. The work of women of any race, especially if it were impactful, was summarily attributed to a white male staffer. Having to work in segregated