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Leadership Development Interventions to Reduce Imposter Phenomenon in the STEM Fields in Minorities

Kristen Merchant
Rose-Hulman Institute of Technology, Terre Haute, Indiana
Associate Director, Union & Student Activities and Director, LEAD programs

Abstract

Background: There is a significant lack of diversity in the Science, Technology, Engineering, and Mathematics (STEM) fields. Evidence shows that lack of representation can feed into feelings of imposter phenomenon which in turn influences leadership qualities. **Objectives:** An argument is made that by providing leadership development training to minorities in science, technology, engineering, and mathematics fields, confidence will be boosted, feelings of imposter phenomenon will be reduced, and thus these students will be retained. **Approach:** Theories explored to explain this challenge include the imposter phenomenon, servant leadership, and transformational leadership. **Results:** The goal of this article is to demonstrate the need for research into leadership development of minorities in the science, technology, engineering, and mathematics fields. **Conclusions:** A program proposal is also introduced as a suggested plan of action based on the findings.

Keywords: STEM, Imposter phenomenon, leadership, servant leadership, transformational leadership, minorities in STEM, leadership development

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Introduction

There is a lack of diversity in the Science, Technology, Engineering, and Mathematics (STEM) fields. According to Van Oosten et al. (2017), only 25% of positions in mathematics and computer professions are held by women. The higher the education or career level in engineering, the more diversity deteriorates. In the article by Jefferson (2019), 24% of doctorates are held by black women, but only 5% of managerial roles are held by black men and women combined, which further highlights the lack of diversity in STEM at the highest education level. The researcher has personal experience as an undergraduate student in the STEM field. During that time, and since, the population of women at the researcher's school has continued to hover around 25% of the student population. Percentages for other minority populations have not made significant improvements either, even though these populations are increasing in college attendance overall. Hispanic workers represent only 15% of the STEM field and American Indians and Alaska Natives make up less than 1% collectively (NSF, 2023, p. 15). Diverse workforces and teams are more likely to keep up with industry trends and markets better than their less diverse competitors (DiLascio, 2022). The positive effects of a diverse workforce further highlight the importance of fostering diverse student success in school and eventually in their careers. The disparity between the benefits of diverse workforces and the lack of diverse students going into these workforces begs the question of "why."

There has been a broad range of research that points to imposter phenomenon being one factor in the low diversity trend. Manongsong and Ghosh (2021) found that high-achieving women are more likely to have feelings of imposter phenomenon which can lead to them leaving their careers. The researcher is interested in examining how leadership development may reduce imposter phenomenon to impact a higher rate of diversity.

Another key factor to know about those in the STEM fields is graduates typically come into the industry underprepared in leadership skills (Farr & Brazil, 2009). "Employers are recognizing that although the necessary technical skills are present, interpersonal skills necessary for effective leadership and collaboration are lacking" and "only 15% of U.S. employers believe that current college graduates are well prepared with regard to awareness of diversity outside the United State" (Akdere, M. et al, 2019). The lack of leadership skills can affect an individual's ability to excel in their careers. In fact, poor leadership skills can impact engineering-dominant companies and can lead to failure to excel in their industries (Farr & Brazil, 2009). Akdere (2019) states that new hires don't lack technical skills; instead, they fail at workplace skills and STEM employers blame academia. To meet the needs of prospective employers, educators should consider introducing leadership development as a prominent component alongside technical skills. In response, educators have begun to research engineering leadership methods, as well as the competencies that employers expect.

Effective leadership skills are crucial for engineers. STEM graduates need professional development to include leadership, communication, and the ability to innovate. However, research has unveiled a significant challenge: the imposter phenomenon. This phenomenon is closely tied to an individual's lack of confidence in their ability to lead. Specifically, it can impact transformational leadership styles (Dominguez-Soto et al., 2021). Transformational leadership, which emphasizes

inspiration, vision, and individual growth, aligns exceptionally well with the demands of the STEM field. The central focus of this article is to explore whether leadership development can mitigate the imposter phenomenon and boost transformational leadership skills. By addressing imposter feelings and enhancing leadership competencies – especially those aligned with transformational leadership, educators anticipate a positive impact on STEM graduates' success and persistence in their STEM careers after graduation.

Definition of Terms

A definition of terms is presented below to provide contextualization. These definitions are through the lens of STEM fields.

Imposter Phenomenon: refers to a psychological phenomenon where individuals have feelings of being a fake in either professional or academic success and is highly linked to perfectionism which can be increased by competitive environments such as in the STEM classroom (Dominguez-Soto et al., 2021).

Transformational Leadership: one method of leading and focusing on motivating the team to exceed their own expectations which focuses on improving morale and increasing employee motivation. Transformational leadership also helps to inspire, motivate, and give direction to their teams (Dominguez-Soto et al., 2021; Ntseke et al., 2022). Essentially, transformational leaders not only drive change but also transform their followers into leaders.

STEM: STEM stands for Science, Technology, Engineering, and Mathematics.

Minorities in STEM: STEM is dominated by white males. For this perspective discussion, any minority in STEM will be **non-white** and **non-male-identifying** individuals.

Theoretical Framework in Current Literature

In preparation for this research, numerous frameworks were reviewed to formulate a design that supports leadership development in STEM fields like engineering. These frameworks will be discussed further in the literature review.

In this review of literature, the researcher establishes critical linkages between STEM disciplines, the impact of the imposter phenomenon, and the imperative for leadership development within undergraduate programs. Throughout the analysis, attention is devoted to global leadership and the unique challenges faced by underrepresented minorities in the STEM fields. The underrepresentation of global leaders, particularly among minorities is a pressing concern. This gap must be rectified to make meaningful solutions to the world's problems. Insights from Main et al. (2019), Mendenhall (2007), and Van Oosten et al. (2017) underscore the urgency of this issue. Bridging the leadership deficit in STEM means that diverse engineering leaders will be ready to lead positive change by harnessing an increase in the diversity of thought in new ideas to solve some of the world's toughest problems.

The STEM Fields

The STEM fields consist of majors in science, technology, engineering, and mathematics. These programs are often incredibly rigorous and competitive. While leaving their undergraduate degrees well adept in technical knowledge, oftentimes students leave their STEM educations lacking in leadership or "soft" skills that will make them truly successful in their professional careers (Robinson et al., 2007). It is not enough for those in the STEM fields to be proficient in their technical skills alone. Scientists, engineers, and mathematicians must also be proficient in professional skills such as leadership, communication, and teamwork (Main et al., 2019; Ntseke et al., 2022; Strubbe, 2022). Though many will start at a lower level as engineers, having the right leadership and teambuilding skills will allow them to move up and contribute to their organizations much quicker. Today's graduates are tasked with responsibilities earlier in their careers than in the past. This is due to the changing dynamics of organizations that operate on flatter hierarchies due to an aging workforce. While leadership skills will make them more successful, employers feel it is the responsibility of higher education institutions to teach these needed leadership skills (Robinson et al., 2007) (McGunagle et al., 2020). Unfortunately, many students lack these professional skills (Main et al., 2019). Challen (2020) emphasizes the importance of a holistic approach to STEM education that includes the arts and leadership to increase critical thinking, inclusivity, empathy, and more.

Main, Wang, and Tan (2019) attempted to examine early career management training (ECMT) as a way of improving leadership roles attained by individuals with PhDs in STEM. There is still room to research earlier leadership interventions in undergraduate STEM fields. Based on their research, ECMT was shown to have a relationship with improved chances of attaining leadership roles for both men and women (Main et al., 2019). This shows promise for leadership development interventions in undergraduate education. Engineers can be stereotypically lacking in communication skills, emotional intelligence, and other leadership skills. So earlier interventions can help engineers gain confidence in these areas and reduce feelings of being an imposter.

Imposter Phenomenon

The definition of imposter phenomenon, for this perspective essay, is a psychological phenomenon that leads individuals to a feeling of being 'a fake' in either professional or academic success. This plague of doubt is highly linked to perfectionism and can be increased by competitive environments in the STEM classroom (Dominguez-Soto et al., 2021). Those underrepresented in the STEM fields, such as women, black, or first-generation students, are more susceptible to feelings of imposter phenomenon due to a sense of "other" or lack of belonging (Dominguez-Soto et al., 2021; Lee et al., 2022). Muslim women are a "minority within a minority" which can result in increased chances of imposter phenomenon. For those women who have persevered, there is an opportunity for mentoring to increase the chances of future generations not feeling so isolated, thus reducing imposterism (Basit, 2022). Good mentors can foster empathy and resilience and help minorities embrace authenticity.

There are a couple of assessments that can help one determine the presence of the imposter phenomenon. Two of these are the Clance Imposter Phenomenon Scale (CIPS) and the Harvey Imposter Phenomenon Scale (HIPS). Of these two, the

CIPS is preferred due to its shorter assessment and higher internal consistency reliability (Chrisman et al., 1995). The CIPS assessment can be found on Dr. Pauline Clance's website and the type of questions that might be expected include: Do you agonize over the smallest mistake or flaw in your work? Do you often feel you are lacking compared to others' accomplishments? Do you worry that others will discover you are not as competent as they expected (Clance, 2013)?

Findings suggest that individuals who score high on feelings of imposter syndrome tend to be less driven to lead (Dominguez-Soto et al., 2021). In the research done by Dominguez-Soto et al. (2021), it was found that the imposter phenomenon could provide indications for how an individual will lead or defer leading to others. If the imposter phenomenon is felt more strongly by certain demographics, this could also help to explain why there is a lack of diversity in the STEM fields.

Minorities in STEM

The imposter phenomenon is the most challenging for individuals who occupy the margins as minorities of a given population. For engineering, the prominent population is white males. Women, racial minorities, etc. would be the minorities in STEM. Table 1 shows a demographic breakdown of individuals in the STEM fields.

Table 1.
Demographics data for STEM-related fields

Household Data Annual Averages						
2023						
		Percent of total employed				
Occupation	Total Employed	Women	White	Black or African American	Asian	Hispanic or Latino
Computer and Mathematical	6502	26.9	63.5	9.2	24	8.8
Architecture and Engineering	3602	16.7	78	6.1	13.1	10.1
Life, Physical, and Social Science	1870	49.8	71.8	8.2	16.5	9.9

**numbers in thousands*
Source: U.S. Bureau of Labor Statistics, 2023

Jefferson's illuminating study (2019) on Black Women in STEM Leadership reveals a stark reality. While it is impressive that 24% of doctorates are earned by black women, their representation in managerial or leadership roles is a dismal 5% held by black men and women combined. Additionally, the gender disparity persists - women only hold 25% of the positions in mathematics or computer professions and only 12% in engineering professions (Van Oosten et al., 2017). This glaring lack of diversity underscores the pressing need for more inclusive and equitable leadership in the STEM field. Attrition rates in the STEM fields are notably high, especially among women, first-generation students, underrepresented minorities, and those with lower incomes. The prevalence of the imposter phenomenon is believed to be a significant contributing factor to this trend. (Liou-Mark et al., 2018; Maxwell et al., 2023).

In Van Oosten et al's. (2017) work with the Leadership Lab for women, the researchers see the need to focus not just on external factors such as gender bias, but also to look at more subtle, invisible factors and to work to develop skills that will help them to persist and succeed. Previous studies have revealed that professional development opportunities can foster career advancement in women (Main et al., 2019). Skills such as self-efficacy, adaptability, and personal vision can all affect women's ability to persist (Van Oosten et al., 2017).

Once in the STEM fields, women who hold PhDs and continue their professional development can internalize leadership roles and reduce gender bias in the workplace (Main et al., 2019). Minorities in STEM benefit from safe spaces where they can receive mentoring, professional development, and other opportunities that can assist in boosting their leadership development opportunities (Jefferson, 2019). Additionally, coaches and mentors are beneficial to women in the STEM fields (Van Oosten et al., 2017). A leadership principle that is highlighted by Strubbe et al. (2022) is the importance of shared ownership and a sense of belonging. This is shown to be important to minorities in STEM and could be a factor related to reducing the imposter phenomenon (Lee et al., 2022).

Leadership

Leadership is not a position, but rather, a series of actions. The related skills to leadership are defined as communication, teamwork, empathy, critical thinking, trust, and encouragement, among others (Challen, 2020; Liou-Mark, 2018; Main et al, 2019; MacIntrye, 2016; Suleman 2018). Transformational leadership is one method of leading and focuses on motivating, inspiring, and empowering the team and its individual members to exceed their own expectations (Dominguez-Soto et al., 2021; Ntseke et al., 2022). There are significant indicators that transformational leadership is associated with a global mindset (Osland et al., 2006). A global mindset enables leaders to appreciate and adapt to different cultures, perspectives, and challenges while maintaining a clear vision and purpose. By combining transformational leadership with a global mindset, aspiring leaders can amplify their impact and collaborate across borders. Not only that, but it can lead to greater global team effectiveness and cohesion (Ntseke et al., 2022). If transformational leadership development is adopted, this could assist in developing global engineering leaders. However, if students with imposter phenomenon are shown to struggle with transformational leadership, then the need for leadership development will be necessary to find a way to minimize the feeling of imposterism. The use of a global leadership curriculum could provide some of the skills necessary to combat feelings of imposter phenomenon, thus increasing abilities as transformational and global leaders (Gagnon, 2013; Ntseke, 2022).

Figure 1
Impact of Leadership Intervention

Source: Author's illustration (2024)

Global Leadership Development

Beyond mastering technical knowledge, STEM professionals must also have strengths and skills in leadership (Main et al., 2019; Strubbe, 2022). Companies increasingly seek leaders who bridge cultural divides with skills in intercultural communication and empathetic leadership (Osland et al., 2017). There needs to be a focus on global leadership skills specifically since STEM professionals can expect to collaborate with diverse teams on complex projects. Numerous studies show that companies need and expect leaders who communicate interculturally and have empathy for a variety of backgrounds and cultures (Osland et al., 2017). Empathy becomes a catalyst for innovation. Developing inclusive leadership in STEM is important and requires an inter-disciplinary approach to meld technical expertise with emotional intelligence, cultural awareness, and collaboration (Challen, 2020; Hudson et al., 2012; Strubbe, 2022). To nurture well-rounded STEM leaders, experiential leadership training is vital. Study abroad immersion opportunities would be one way to accomplish this (Davidson et al., 2017; Strubbe, 2022). Global immersion opportunities can help develop skills that are associated with transformational leadership such as listening, open-mindedness, and encouraging, as well as developing a global mindset (Davidson et al., 2017; Suutari, 2002). Within the global leadership development curriculum, the use of the Global Mindset Inventory which was created at Arizona State University's Thunderbird School of Global Management, would be another way to focus on student global development (ASU, 2020).

A study by Liou-Mark et al. (2018) looked at peer-led leadership teams with an expectation of collaborative learning. The imposter phenomenon is typically exacerbated by a competitive environment, so focusing on peer-led, collaborative learning for under-represented students in STEM could reduce imposter syndrome (Dominguez-Soto et al., 2021). The use of a peer-led team learning program in a biology course demonstrated a significant impact on imposter phenomenon (Maxwell, 2023). Higher education institutions should implement peer cohort leadership programs aimed at mitigating imposter phenomenon and enhancing leadership skills among STEM majors. (Palid et al., 2023). It is a goal of this researcher to explore the

feasibility of such a program and assess its impact on students' growth and development.

In a study by Main, Wang, and Tan's (2019), participants reported increased confidence and improved leadership after receiving training, regardless of the content of the training. This positive impact extends beyond the individual growth of the participant; it also contributes to reducing career inequality. These findings have led to the following research question: Can early interventions focused on global leadership affect imposter phenomenon, particularly for minorities in the STEM fields?

Program Proposal

Based on the evidence provided above, the researcher proposes the implementation of a Global Leadership Development program. This program will address some of the concerns and reduce the feelings of imposter phenomenon, increase transformational leadership skills, and persistence in their STEM careers (both educationally and vocationally).

Strategic Plan: Empowering STEM Minorities through Global Leadership Development at a small, private STEM-focused institution

Goal:

Implement an early intervention leadership program centered around global leadership skills, with the goal to reduce imposter phenomenon and enhance leadership skills among underrepresented minorities in STEM fields and thus increase persistence.

Objectives:

1. **Identify Target Population:**
   - 1.1. Define the target audience: undergraduate and graduate students from diverse backgrounds pursuing STEM degrees.
   - 1.2. Prioritize minorities, including women, racial and ethnic minorities, and first-generation college students.

2. **Develop Program Design and Curriculum:**
   - 2.1. Collaborate with faculty, industry experts, and leadership development specialists to design a comprehensive curriculum.
   - 2.2. Incorporate global leadership competencies, emphasizing cross-cultural communication, adaptability, and empathy.
   - 2.3. Blend theoretical knowledge with practical experiences through workshops, seminars, and experiential learning.

3. **Integrate Transformational Leadership:**
   - 3.1. Inspire a Vision: Transformational leadership focuses on inspiring a vision.
     - 3.1.1. Infuse the program with a vision of inclusive STEM leadership that transcends borders.
     - 3.1.2. Focus on educating on how to inspire vision for others.
   - 3.2. Empower and Motivate: Transformational leaders empower participants to take ownership of their roles. Encourage students to lead with confidence and resilience.

4. **Develop Global Mindset:**
   - 4.1. Understanding and Embracing Different Cultures: A global mindset requires understanding cultural nuances. We will expose students to diverse perspectives and foster cultural intelligence.
   - 4.2. Openness and Adaptability: Transformational leaders embrace change. We will cultivate openness to new ideas, adaptability, and a willingness to learn from global contexts.

5. **Facilitate Experiential Learning Opportunities:**
   - 5.1. Study Abroad Immersion: Create study abroad partnerships and opportunities for students to utilize and experience various cultures while applying their STEM knowledge.
     - 5.1.1. Provide scholarships or grants to reduce the barrier for entry for STEM students to participate in international study programs.
   - 5.2. Internships and Research Abroad: Facilitate global internships or research experiences.
   - 5.3. Virtual Exchange Programs: Creating another method for students to gain global experiences.
     - 5.3.1. Connect students with peers from diverse countries through virtual platforms.
     - 5.3.2. Provide alternative options to in-person study abroad opportunities.

6. **Assess and Evaluate:**
   - 6.1. Regularly assess participants' imposter feelings using validated scales (e.g., Clance Impostor Phenomenon Scale).
   - 6.2. Measure leadership skill development through self-assessment, peer evaluations, and faculty feedback.
   - 6.3. Collect qualitative data on participants' experiences and growth.

7. **Train Faculty and Staff:**
   - 7.1. Train faculty and advisors in transformational leadership principles.
   - 7.2. Sensitize them to the unique challenges faced by minority STEM students.
   - 7.3. Encourage faculty to develop global study opportunities.
   - 7.4. Provide workshops to assist faculty in entwining global leadership principles in their classrooms.

8. **Integrate Community Engagement:**
   - 8.1. Collaborate with industry partners, alumni, and STEM organizations.
   - 8.2. Host guest speakers, panels, and networking events.
   - 8.3. Foster a sense of belonging and community among participants.

9. **Foster Campus Partnerships:**
   - 9.1. Center for Global Engagement to assist in increased global mobility.
   - 9.2. Leadership Development office to guide leadership development education practices.
   - 9.3. Career Services to build partnerships globally with various businesses to provide internship and job opportunities.
   - 9.4. Community Engagement office to connect campus with potential organizations and partners.

9.5. Curriculum Committee to implement additional curriculum requirements into course offerings and potential degree requirements.

10. Long-Term Impact:

10.1. Track participants beyond graduation to assess career trajectories, leadership roles, and imposter feelings.

10.2. Establish an alumni network to support ongoing professional development.

11. Continuous Improvement:

11.1. Regularly review and update the program based on participant feedback and emerging research.

11.2. Seek external funding and grants to sustain and expand the initiative.

Conclusion

By integrating transformational leadership principles and fostering a global mindset, we empower STEM minorities to lead with authenticity, resilience, and a vision that transcends borders.

Summary

Women have demonstrated stronger skills in being transformational leaders than men. Developing these leadership abilities can enhance career growth for women. However, there remains a significant underrepresentation of women (and other minorities) in STEM fields. (Dominguez-Soto et al., 2021; Van Oosten et al., 2017). The imposter phenomenon, which is associated with a lack of confidence in leadership skills, often leads to early discontinuation of education. This phenomenon could be a key factor contributing to the limited persistence of women and other minorities in the STEM careers. Since leadership development has been shown to increase leadership success later in careers, it would seem relevant to look at early interventions for leadership development that could improve the confidence of the individual, thus reducing imposter phenomenon and increasing skills as transformational leaders and persistence through their education and careers (Dominguez-Soto et al., 2021; Main et al., 2019). Components of transformational leadership such as motivating and inspiring team members to reach their potential can help to warm the “chilly climate” of the STEM fields which often leads to minorities in STEM leaving the field (Ntseke et al., 2022; Palid et al., 2023). Finding ways to increase retention of minorities in STEM, both in education and later in their career, is critical. By developing more transformational global leaders in the underrepresented STEM populations, this could prove beneficial in overall retention in the field. As previously mentioned, diverse workforces are more innovative and productive. By researching ways to reduce the imposter phenomenon through early education leadership interventions, it is possible to impact retention of diverse talent. In summary, addressing imposter feelings and supporting transformational leadership skills are crucial steps toward creating a more inclusive and successful STEM workforce.

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About the Author

Kristen Merchant, a Terre Haute local, found her passion in guiding students at Rose-Hulman after falling in love with her own undergraduate experience there. Her role as Associate Director of Union & Student Activities offers a variety of experiences, from campus events to leadership training, keeping every day exciting. In addition, directing Rose-Hulman's Leadership Education and Development (LEAD) program has sparked a new enthusiasm for nurturing students' leadership skills. In the fall of 2022, Kristen pursued her other passion of education and began her journey in the Ph.D. in Global Leadership program at Saint Mary-of-the-Woods College, in Terre Haute, Indiana. Outside of work, Kristen enjoys decorating her first home with her husband, being a dog mom, and indulging in cozy reading sessions. She also enjoys playing on the "Girls that Golf" team in the intramural league, despite their lack of skill.