



# Power of shared success: how can sharing success and roles of others motivate African women in STEM?

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## Abstract

This study examines the success and role of African women leaders in science, technology, engineering, and mathematics (STEM). In the absence of significant research on women's STEM leadership, the success and roles of others could motivate an aspiring African woman to pursue a career in STEM. A qualitative approach was sought using open online questions and narratives from African women leaders about their roles and career success in STEM. Data were collected from the western, eastern, northern, and southern regions of Africa from participants who held STEM leadership positions, such as directors, deans, and chief officers. The participants were 42 women representing 12 African nations. The narratives of these women leaders' tones and life experiences were analyzed through content analysis. The narratives of these women leaders' tones and life experiences were analyzed in search of recurring patterns and themes. Successful leadership in STEM requires balancing career and family life, setting goals, solving problems, being open to innovative ideas, embracing diversity, collaborating, and having knowledge of STEM research and mentoring skills. Using the achievements and roles of others could inspire future African women to pursue careers in STEM.

**Keywords** Career paths · Female scientists · Gender inequality

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## Résumé

**Le pouvoir du succès partagé: Comment le partage du succès et du rôle des autres peut-il motiver les femmes africaines dans les STEM?** Cette étude examine le succès et le rôle des femmes africaines dirigeantes dans le domaine des sciences, de la technologie, de l'ingénierie et des mathématiques (STEM). En l'absence de recherches significatives sur le leadership des femmes dans les STEM, le succès et les rôles des autres pourraient motiver une femme africaine à poursuivre une carrière dans les STEM. Une approche qualitative a été menée en utilisant un questionnaire en ligne et des récits de femmes dirigeantes africaines sur leurs rôles et leur réussite professionnelle dans les STEM. Les données ont été recueillies dans les régions occidentales, orientales, septentrionales et australes de l'Afrique auprès de participantes ayant occupé des postes de direction dans le domaine des STEM, tels que directrices, doyennes et directrices générales. Les participantes étaient 42 femmes représentant 12 nations africaines. Les récits des tonalités et des expériences de vie de ces femmes dirigeantes ont été analysés par le biais d'une analyse de contenu. Les récits des tonalités et des expériences de vie de ces femmes dirigeantes ont été analysés à la recherche de modèles et de thèmes récurrents. Un leadership réussi dans le domaine des STEM exige de trouver un équilibre entre la carrière et la vie de famille, de fixer des objectifs, de résoudre des problèmes, d'être ouverte aux idées novatrices, d'embrasser la diversité, de collaborer et d'avoir une connaissance de la recherche dans le domaine des STEM et des compétences en matière de mentorat. L'utilisation des réalisations et des rôles des autres pourrait inspirer les futures femmes africaines à poursuivre des carrières dans les STEM.

## Zusammenfassung

**Die Macht des gemeinsamen Erfolgs: Wie kann das Teilen von Erfolgen und die Rolle anderer Frauen afrikanische Frauen für die MINT-Branche motivieren?** Diese Studie untersucht den Erfolg und die Rolle afrikanischer weiblicher Führungskräfte in den Bereichen Mathematik, Informatik, Naturwissenschaft und Technik (MINT). In Ermangelung aussagekräftiger Forschungsergebnisse über weibliche MINT-Führungskräfte könnten der Erfolg und die Rolle anderer Frauen eine aufstrebende afrikanische Frau dazu motivieren, eine Laufbahn in der MINT-Branche anzustreben. Es wurde ein qualitativer Ansatz verfolgt, bei dem offene Online-Fragen und Erzählungen von afrikanischen weiblichen Führungskräften über ihre Rolle und ihren beruflichen Erfolg im MINT-Bereich verwendet wurden. Die Daten wurden in den westlichen, östlichen, nördlichen und südlichen Regionen Afrikas von Teilnehmerinnen gesammelt, die Führungspositionen im MINT-Bereich innehatten, z. B. als Direktorinnen, Dekaninnen und Vorstandsvorsitzende. Die Teilnehmerinnen waren 42 Frauen aus 12 afrikanischen Ländern. Die Erzählungen dieser weiblichen Führungskräfte über ihren Tonfall und ihre Lebenserfahrungen wurden mittels Inhaltsanalyse analysiert. Die Erzählungen dieser weiblichen Führungskräfte wurden auf der Suche nach wiederkehrenden Mustern und Themen analysiert. Erfolgreiche Führungsarbeit in den MINT-Bereichen erfordert die Vereinbarkeit von Beruf und Familie, das Setzen von Zielen, das Lösen von Problemen, die Offenheit für innova-

tive Ideen, die Akzeptanz von Vielfalt, die Zusammenarbeit sowie Kenntnisse in der MINT-Forschung und Mentoring-Fähigkeiten. Die Nutzung der Errungenschaften und Rollen anderer könnte künftige afrikanische Frauen dazu inspirieren, eine Laufbahn im MINT-Bereich einzuschlagen.

## Resumen

**El poder del éxito compartido: ¿Cómo puede el éxito compartido y el papel de los demás motivar a las mujeres africanas en STEM?** Este estudio examina el éxito y el papel de las mujeres africanas líderes en ciencia, tecnología, ingeniería y matemáticas (STEM). En ausencia de investigaciones significativas sobre el liderazgo de las mujeres en STEM, el éxito y el papel de otros podrían motivar a una mujer africana aspirante a seguir una carrera en STEM. Se buscó un enfoque cualitativo mediante preguntas abiertas en línea y narraciones de mujeres líderes africanas sobre sus funciones y su éxito profesional en STEM. Se recopilaron datos de las regiones occidental, oriental, septentrional y meridional de África de participantes que ocupaban puestos de liderazgo en STEM, como directoras, decanas y jefas. Participaron 42 mujeres que representaban a 12 naciones africanas. Las narraciones de los tonos y las experiencias vitales de estas mujeres líderes se analizaron mediante análisis de contenido. Las narraciones de los tonos y las experiencias vitales de estas mujeres líderes se analizaron en busca de patrones y temas recurrentes. El liderazgo exitoso en STEM requiere equilibrar la vida profesional y familiar, establecer objetivos, resolver problemas, estar abierto a ideas innovadoras, abrazar la diversidad, colaborar y tener conocimientos de investigación en STEM y habilidades de tutoría. Utilizar los logros y las funciones de otros podría inspirar a las futuras mujeres africanas a seguir carreras en STEM.

## Introduction

Organizations depend on their human capital, a key driver of economic progress, to promote development and achieve their vision and goals. Sex differences in participation in science, technology, engineering, and mathematics (STEM) have been constant over the years (Stoet & Geary, 2018). It is expected to impact the occupation of leadership positions in organizations, including STEM-related organizations. Gender disparities in STEM participation vary from country to country and culture to culture (Su & Rounds, 2015); the causes may vary between developed and developing nations. According to studies, STEM vocational education could change our society and labor market (Benavent et al., 2020; National Research Council (NRC), 2012); Sanders, 2009) since the gender gap in higher education also persists in the workforce (Bennett et al., 2021).

To help advance the Sustainable Development Goals (SDGs), which include equity, diversity, and justice, and to educate children, especially girls (General Assembly, 2020; UNDESA, 2017), women need mentoring and leadership training

to take decisive action and express themselves forthrightly. Similarly, fairness and diversity are essential for educational sustainability, reducing gender stereotypes, and encouraging long-term attitude changes. In both formal (schools and universities), informal (social relationships and leisure activities), and non-formal (families and workplaces), forums help shape gender-based attitudes (Lucchini & Dodman, 2015). It helps sustain and promote enrichment, growth, and flexible change (Di Fabio, 2017).

Most women desire upward mobility to become a leader (Ibarra et al., 2013) in the workplace in any organization of operation. For example, the experience associated with workplace administration includes acquiring unique skills and competencies, adjusting to the necessary office style, motivational needs, recognition (affirmation), and motivation (Ibarra et al., 2013). However, a study indicated that women's labor market outcomes could hinder their STEM careers (Professionals Australia, 2018), driven by the perception that they lack confidence in technical fields (e.g., Sobel et al., 2016). In many African nations, cultural traditions severely restrict women's rights (Ncube, 2010), as the authority of male leaders is not questioned. For example, the patriarchal conception of women as subordinates restricted them to the private domain (Poltera & Schreiner, 2019), while Ebert et al. (2014) reported that female leaders in STEM faced stereotypes of incompetence and managerial failure.

A healthy workplace should be where employees (whether men or women scientists) work together to improve and sustain themselves and the organizational goals. These goals require a leader who catalyzes healthy work cultures (Ardichvili et al., 2016), as the workplace is where almost a third of work lives are spent. No wonder (Ziskin, 2015) asserted that organizations should develop individual leadership capacity and concentrate on the organization's capability. Although there is much research on leadership behavior (Ladegaard, 2011), few studies examine women's leadership in STEM in African nations. Some nations have a significant proportion of women on their boards, while others do not (Chizema et al., 2015). The unique difficulty of being a woman in the workplace is not only a barrier to ascending to executive positions but also a barrier to the ability to succeed. Although global connections, increased social investment, and enthusiasm are beneficial, they have not considered established public biases that hinder women's advancement in STEM fields. This survey seeks to investigate and understand African women's leadership and STEM success. The objectives are to investigate African women's career paths and sources of inspiration in STEM and to examine the characteristics of successful and active female leaders in STEM.

## Literature review

One of the vital underlining theories of this research is the social cognitive career theory (SCCT). The theoretical framework illustrates how individual, contextual, and experiential factors influence interests, goals, and goal-directed behavior (Lent et al., 1994). In STEM-related career research, this theory is prevalent (Liu et al., 2014; Turner et al., 2019). Here, career development is influenced by personal,

contextual, experiential, and learning factors. It is assumed that these factors will significantly affect how STEM women achieve leadership. Self-efficacy beliefs are subjective convictions that individuals can complete specific tasks in which the outcome expectations are the convictions that these behaviors will produce specific outcomes (Lent et al., 1994). The theory identifies structural barriers and support as career advancement impediments (Lent et al., 1994). Contextual barriers cause psychological distress (Wilkins-Yel et al., 2022). Individuals with a strong belief in self-efficacy are more likely to become interested, pursue, and perform better activities related to these beliefs if they possess the necessary skills and support systems. Advisors, peers, professors, and significant others can ease the psychological toll of contextual barriers on women in STEM leadership. SCCT explains gendered expectations, interests, and aspirations. STEM women may be confident because they overcame obstacles to work in male-dominated fields (Bennett et al., 2021). Studies by Lee et al. (2015) and Navarro et al. (2014) on women and minorities in STEM support the assertion of SCCT. Thus, this study investigates the career path of STEM women in leadership to success.

Research on self-sacrifice also revealed that women leaders are more likely than men to report self-sacrifice as a component of their behavior (Arnold & Loughlin, 2010). The development of women's leadership is attributable to the interactions of perceived individual disposition (Furst & Reeves, 2008), such as locus of control (Sharma & Tarp, 2018). The effect of personal inclination is central to the rise of leadership. Based on Kegan's (1982) theory of adult development, people learn and develop most effectively when they oversee their products (Petrie, 2014). Although gender differences in leadership characteristics were not as apparent among executives, dispositional differences were more significant among women than men (Wille et al., 2018). The advancement of women to board positions is uncommonly low in state-owned institutions (Chizema et al., 2015).

Contextual factors influencing women's leadership are shown primarily in a group with more men. In groups with most women, neither men nor women emerge as leaders (Lemoine et al., 2016). Thus, women leaders often distinguish between appearing too manly and too womanly (see, e.g., Binns, 2008). Behavior like this aligns with the role congruity theory (Eagly & Karau, 2002). Role congruity theory states that women must exhibit a more balanced style with a greater focus on gender behaviors and "leader"/male behaviors to conform to female and leader stereotypes and succeed in a masculine environment. According to the role congruity theory, women must demonstrate a more balanced style with a greater emphasis on gender behaviors and "leader"/men behaviors to conform to women and leader stereotypes and be successful in a masculine environment.

Parker et al. (2018) and Wang et al. (2013) demonstrated that women's underrepresentation in STEM is associated with gender differences in self-concept ability. Self-concept assimilation theory is used to explain gender differences. According to assimilation theory, people who have internalized the stereotypes of a group modify their beliefs and behaviors to conform to widely accepted stereotypes (Brown, 2019). The stereotype could be why STEM women leaders face conflicting incongruent role demands in leadership and gender roles. Male leaders, in contrast, are free to act masculinely. Hirst et al. (2004) used an action learning theory perspective

to explain that leaders learn from challenging tasks such as resolving complex problems, leading a team, and applying this knowledge to improve communication and performance. Leaders who are more able to learn from their experiences show higher levels of facilitative leadership. Consequently, a leader's level of proficiency will indicate how much they have learned (Hirst et al., 2004). However, despite roadblocks, several women have achieved high administrative positions, allowing researchers to explore factors related to their achievement.

Generally, specific skills are necessary for a leader's career path (Mumford et al., 2000), with a gradual refinement of skills, information processing, and knowledge structures (Day et al., 2014). Work orientation, mastery orientation, and career advancement orientation are essential for leadership development (Boyce et al., 2010). However, the study by Billhuber Galli and Müller-Stewens (2012) revealed that social capital could affect leadership development practices due to contact characteristics of social networking, mentoring, and assimilation arising from leadership training, 360-degree feedback, and identification with job assignments and action learning.

## Research goals

The research goal of this study was as follows:

- (1) Explore the career path and sources of inspiration of African women in STEM to attain leadership positions.
- (2) Explore the characteristics of successful women leaders in STEM

## Methods

### Research approach and study design

This study provides an in-depth, exhaustive, and comprehensive study of women's leadership success and STEM roles in Africa using a qualitative descriptive design (Sandelowski, 2010). The design of this study allowed us to remain close to the data, comprehend the meaning participants assigned to their thoughts and beliefs, reduce research biases, and obtain direct answers to our research questions. Using qualitative description (Kahlke, 2014) was also consistent with our primary objective of describing and comprehending the subjective nature of the participants' stated motivations. A similar procedure was also used by Sáinz et al. (2020).

Exploratory research requires more information and insight about a problem or opportunity, and data collection contributes to formulating more pertinent research questions (Wiid & Diggines, 2020). Therefore, the adoption and use of an open-ended self-administered questionnaire with STEM researchers from North, West, East, and Southern Africa make it possible to examine how female managers in these African nations perceive their ascent to leadership positions. In addition, it allows researchers to think about what is happening in each context. There is no

unified African culture or context, as diverse racial, socio-cultural, ethnic, and historical norms influence power relations and how women should lead (Lituchy et al., 2017). Northern African nations, for example, have a lower proportion of women in formal leadership positions than sub-Saharan African nations (Punnett & Clarke, 2017). Therefore, this study sought to identify the success of women in leadership and STEM roles in Africa.

## Participants

The participants were 42 women in leadership positions from 12 African nations. They came from various geographical regions of Africa: Cameroon, Egypt, Ghana, Kenya, Malawi, Nigeria, Rwanda, South Africa, Sudan, Uganda, and Zimbabwe. The sample size was adequate to obtain a variety of perspectives and points of view and to gain an in-depth understanding of the required experiences (see Singh et al., 2017). The small sample size in the present study reflects the number of willing participants in African nations. Numerous languages and ethnic groups contribute to the diversity of Africa. However, the Ubuntu philosophy, which defines the individual in terms of others, reflects a sense of communal belonging (Lituchy et al., 2017; Poltera & Schreiner, 2019).

Each participant was purportedly selected for their leadership role (lecturers, professors, heads of departments, deans, and directors) at universities and research institutes. The choice of academia was based on similarity in the structure of educational institutions on the African continent. Non-probabilistic, purposive, and convenient sampling was employed. Science education, engineering, health sciences, physical sciences, biology, and allied sciences were represented. Education levels range from diploma to doctorate, and ages range from 25 to 65. With two to 26 years of work experience, African women leaders in STEM were selected as study participants because they were qualified to participate. The demographic details of the participants are presented in Table 1.

## Procedure

Potential participants were reached through research scholar links and other social networks. Universities and research institutes in the STEM field were contacted. Participants who expressed interest received the study's written information and consent forms. Potential participants had ample time to submit consent forms; if they did not, they were contacted to ensure they had received the information. Due to the diverse geographic locations, the surveys were administered by e-mail. E-mails were sent to research institutes, and universities requesting the participation of women STEM leaders. It took two months to complete the data collection, from the initial contact with the respondents to the last response. The semi-structured question through e-mail was adopted because of the desire to have more nations represented and the challenge of pinning down most leaders. The questions also included consent forms for the study participants. The document allowed free discussion of STEM-related participant experiences, with no limits on the number of words or statements

**Table 1** Demographic table showing the designation, education, years in leadership, and age

Item	East			North			South			West			Total
	Kenya	Rwanda	Sudan	Uganda	Egypt	Malawi	Lesotho	S. Africa	Benin	Cameroun	Ghana	Nigeria	
<i>Designation</i>													
Dean	1							1				1	3
Director	2			1		1		5				3	12
HOD	1						1	1				2	4
Professor					1			1	1		1	4	8
S. lecturer	2		2					1		1		2	8
Lecturer	3			2								2	7
Education													
Ph.D.	6	1	2		1	1	1	6	1	1	1	14	35
MSc	2			2									4
BSc/BTech								2					2
Diploma								1					1
<i>Years in leadership</i>													
2–5	5	1	2	1		1		6		1		6	23
6–10	2			1			1	1	1		1	5	12
11–15												3	3
16–20	1				1								2
21–25													1
Above 26								1					1
<i>Age</i>													
25–34								1					1
35–44	2			2	1			2	1	1		4	13
45–54	3	1	1			1	1	2				5	13



Table 1 (continued)

Item	East			North		South			West			Total	
	Kenya	Rwanda	Sudan	Uganda	Egypt	Malawi	Lesotho	S. Africa	Benin	Cameroun	Ghana		Nigeria
55-64	3		1					3			1	4	13
65+ Older								1				1	2
Total	8	1	2	2	1	1	1	9	1	1	1	14	42

on women's leadership roles in the workplace. However, the procedure did not allow participants to be questioned for further comments. All research protocols were approved by North West University, South Africa.

### **Data collection**

The vital component of the survey consisted of an open and self-administered questionnaire on leadership success and STEM roles. The structure of open-ended questions with prompts allows respondents to provide detailed information about their experiences. The questionnaire included a demographic section to describe the sample group and seven open-ended narrative questions. Each item includes demographic and employment-related information. The question focused on the success and role of STEM women leaders in Africa. The questions were sufficiently open to allow participants to respond according to their ideas and perspectives, thus allowing the study to gather unique, deliberate, and accessible data (Saunders et al., 2020). Specifically, the questions focused on (1) How would you describe a woman's career path in STEM? How does she attain the position of leadership? (2) Who inspires a woman in STEM to pursue a leadership position? (3) What does successful STEM leadership mean for women in STEM leadership positions? (4) What qualities does a woman need to possess to be an active STEM leader?

### **Data Analysis**

The analysis adopted a systematic and transparent process that involved familiarization, theme identification, indexing, mapping, and interpretation (Ritchie et al., 2013). The researchers checked the accuracy of the interview response statements and read them to facilitate familiarization with them. The initial thematic structure and themes were identified. The attributes and characteristics of each theme and their interrelationships were documented. The researchers independently performed each step of the analytic procedure to improve the reliability of the study. They then discussed their findings and agreed on the final thematic structure and explanatory accounts.

It should be noted that categories were independently coded and discussed before finalizing the coding, and the consensus was used to improve categorization and reduce bias (Amon, 2017; Kreiner et al., 2009). The techniques used to isolate the analysis elements were concept identification and categorization to develop the coding scheme. The adopted procedure was consistent with the research (Shoffner et al., 2015).

### **Open coding**

The research team developed a provincial coding scheme to analyze the data by constructing categories and a coding scheme to present the necessary items. When coding issues arose, the group discussed possible solutions (revise or add another). The coding scheme was changed to accommodate the lack of clarity in achieving

agreement, which was purified when necessary. An independent assistant was invited to rate each item based on the final coding scheme and definitions to ensure that the scheme was meaningful and valuable (Hill et al., 1997). The coders assigned a positive, neutral, or negative valence to each outcome category. Ratings were discussed when there was disagreement until a consensus was reached. After coding, the categorized outcome was created as a graphic representation.

### **Ethics and trustworthiness considerations**

The study obtained permission from the university's ethics review committee to use the protocol to collect data. The researcher also took trustworthiness and ethical considerations into account. The researchers assured the participants of the confidentiality of the information collected; the respondent, the institution's identity, and the country represented remain anonymous.

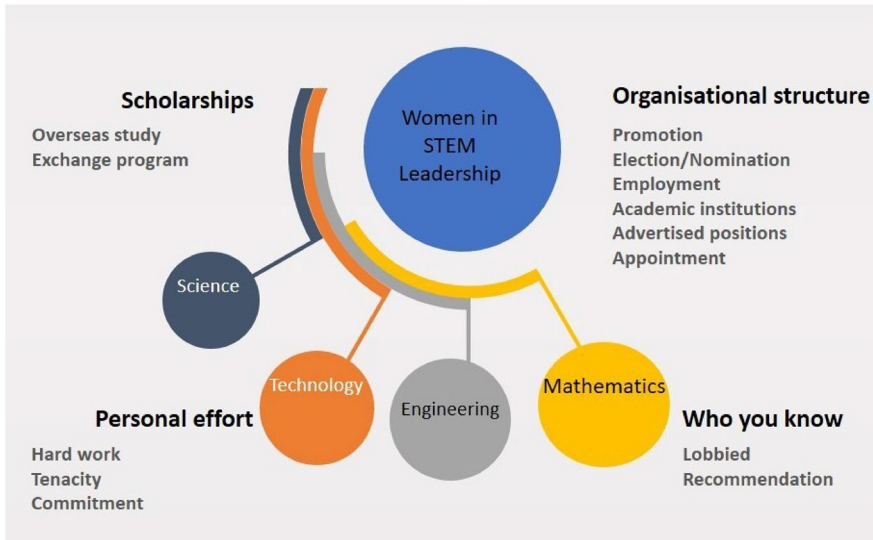
### **Results**

Research findings detailing the responses to the four research questions are presented following data analysis. The questions are as follows: (1) How would you describe a woman's career path in STEM? How does she attain the leadership position? (2) Who inspires a woman in STEM to pursue a leadership position? (3) What does successful STEM leadership mean for women in STEM leadership positions? (4) What qualities do women need to be active STEM leaders? Participants held various positions and titles within their organizations, including lecturers, professors, researchers, deans, heads of departments, or chief officers. Their credentials ranged from MSc and Ph.D. to equivalents.

### **Organizations in STEM and participants' profile**

Demographic data were based on designation, education, years of leadership, and age (Table 1). Science education, engineering, health sciences, physical sciences, and allied sciences were among the areas of expertise. Figure 1 shows a graphical representation of the participating nations. These regions represent East, South, and West Africa. Participants from Kenya, South Africa, and Nigeria who had the opportunity to be there in person are prominent in the study.

Thirty-four respondents have the highest academic qualification of doctorate degrees. Twenty-three respondents have 2–5 years of leadership experience, while the highest number of participants, 14, is between the 45–54-year brackets. Of the 42 respondents, 19 are in management positions, such as dean, director, and head of the Department. Participants held various positions and titles within their organizations, including seven lecturers, eight senior lecturers, eight professors, three deans, four heads of departments, and 12 directors.



**Figure 1** Career path and the attained position: Scholarship, organizational structure in place, commitment, hard work, tenacity, and appointment all formed tools for women's career paths and attained positions. *Source* author's work

### **Research Question 1: How would you describe a woman's career path in STEM? How does she attain the position of leadership?**

The path of career and inspiration sources are women in STEM who aspire to leadership positions.

#### **Career path and the attained position**

##### **Scholarship**

Some participants' career paths (Figure 1) indicated a full scholarship from primary school to university due to exemplary performance. For example,

During my high school education, *I was in class*, and some guys arranged to beat me up. Thus, I could not join the pure mathematics class because I was the only lady who opted to do that course (P1/Ghana/55-64).

##### **The organizational structure in place**

Due to a supportive organizational structure, many women advanced in their careers, e.g., from seven years as a high school teacher to section head. In most cases, they began as a junior or assistant lecturer. After earning their master's and doctoral degrees, they advanced through the ranks until they became professors. In addition, many viewed the doctorate as the pinnacle of their career path.

I was employed as an assistant lecturer, and now I am a senior lecturer. I was the coordinator of the Student Industrial Work Experience Scheme for the Crop Science and Technology Department at the School of Agriculture and Agricultural Technology. I was in charge of the two and four years of students, totaling about nine hundred students. (P36/Nigeria/35-44)

*Armed with a Ph.D.*; my career was, therefore, a default, I am a lecturer and researcher, and the leadership position as the director of the School of Environmental and Health Sciences was advertised, and I responded to an advertisement (P27/South Africa/65-74).

I started as a *nursing student and rose to become the head* of the Department of Nursing (P5/Nigeria/45-54)

The study aimed to determine the career paths and how success was achieved in their current positions. Most of the respondents indicated that their careers began in an academic institution. Many attested that the current position began when appointed as the head of the department. The other route is institutional reorganizational processes. Some individuals obtained their positions through standard promotion applications. In addition, others were placed after successful interviews in the advertised positions, while others were assigned to act in another institution. The following statement accurately describes how the participants' careers began:

I started as a junior lecturer. I then studied for my Master's and Ph.D. and *was promoted through the ranks until becoming a Professor*. I became acting dean through the restructuring process and then applied for the position of Deputy Dean. (P3/South Africa/55-64)

Similarly, other participants followed the following.

I started as an assistant lecturer and rose to become a professor. During my career, I have been doing administrative and consulting work for organizations within and outside Nigeria (P5/Nigeria/45-54).

These excerpts demonstrate how education affects women's career paths of women. Due to their educational attainment and experience, women hold leadership positions in the Department of Education. Some superiors influence the career paths of their subordinates by serving as role models and mentors in the workplace.

### **Personal effort**

In some cases, women were appointed based on their friendliness and ability to work with diverse groups. Several people who followed the STEM career path ended up in academia because they had no other employment options.

In my final year during my first degree, I represented my group in class to present a group term paper during which our lecturer said 'our future lecturer.' My performance in this encouraged me to apply for Ph.D. I applied to my Master's program immediately after National Youth Service Corp because I had nothing else to do. After that, I got a job as a lecturer II. I was made the

exam officer and secretary of some committees in my Department and now Head of Department (P4/Nigeria/45-54).

Some women achieved their position due to their availability to volunteer in their organizations, such as participating in activities, including teaching, student supervision, community development, research publication, national and international organizations consultation, membership in national and international professional organizations, and more. It has been accomplished primarily through individual efforts, with almost no mentorship and many challenges, self-improvement, perseverance, academic excellence, active participation in research, exposure to international research, and a desire to be a vanguard in the scientific field.

After one year, due to commitment, hard work, and tenacity, I was appointed the SIWES coordinator for the entire school comprising seven departments, totaling about three thousand students (P36/Nigeria/35-44)

I am very interested in the field of applied biomathematics research. I have begun studying in this field because of my efforts, self-supporting, and ability to skip over the restricted constraints and limited resources (P34/Sudan/45-54)

I am the first female head of my Department in its more than 50 years of existence and the first female professor (P5/Nigeria/45-54)

Individuals emphasize the role that the achievement of a Ph.D. plays in their career development.

After completing my Ph.D. studies, I was employed as a lecturer. After two years, I was elected program leader. Overseeing the curriculum, guiding students, taking care of the examination processing, and making sure that all courses are being taught (P28/Kenya/45-54)

After joining the university for undergraduate studies, I did not like the course to which I was admitted (i.e., Bachelor of Education). Therefore, I vowed to work hard and achieve the highest educational qualifications possible. After graduating, I got an appointment to teach in a secondary school in Kenya. While teaching, I enrolled for a Master's degree. I continued teaching in secondary school for three years after graduating. I got a job as Assistant Lecturer in the Department with the condition that I must pursue a Ph.D. Thus, I enrolled in the program immediately, which was how I attained my Ph.D. (P26/Kenya/35-44)

Some people mentioned that they worked their way up the career ladder in self-reflection.

## **Research Question 2: Who inspires a woman in STEM to pursue a leadership position?**

### **The inspiration source for women in their search for STEM leadership**

Participants have been motivated throughout their career stages to strive to be leaders at the secondary school level to varying professional heights. As high school principals, senior researchers and lecturers, master and doctoral supervisors, post-doctoral fellows, heads of departments, directors, deans, and vice-chancellors provided motivation.

One of my female colleagues in the same field, who was also my lecturer in master's degree, and unconsciously she also plays the role of a mentor to me (P40/Cameroun/35-44).

My spouse was/is my mentor. He was a widower, much older than me, and already a Senior Lecturer when we married. He encouraged me to achieve the highest academic qualification. He also wanted me not to be content with being just a partner and a high school teacher, which I did for one year (P24/Nigeria/45-54)

My Ph.D. supervisor inspired my leadership journey. She was a lady, and while I pursued my Ph.D. studies, I was given many department responsibilities. I oversaw the laboratory and all the students who came to the institute for industrial attachment. She was the institute's director, where I carried out part of my research work (P28/Kenya/45-54).

However, except for fathers and spouses (sometimes mentors), the participants claimed that most of their inspiration came from women. For example,

A doctorate in ICT inspired me that, though it is a male-dominated field, women can make it if we try harder. She appointed me as a class representative and a student assistant in her class. I loved how she interacted with everyone regardless of social and cultural background. She could create a niche for herself in the education arena. She was the first principal of a government girls' school and rose to become Director of the Department of Education. She exhibited very high levels of integrity while she worked her way up (P12/South Africa/25-34).

However, some reported being inspired by co-workers from men (note: not father or spouse).

Having role models who mentor young women can help those aspiring to enter leadership positions. Mentoring can also be provided by males occupying senior management positions (P33/Lesotho/45-54).

In contrast to the above, some participants indicated that they were motivated by reading books and believing they could accomplish anything they set their minds to. However, in many other cases, they mentioned that they were confident with no push from anyone! Specifically, they believe in themselves. These individuals are familiar

with personal motivation, secure command, and the ability to maintain STEM excellence successfully.

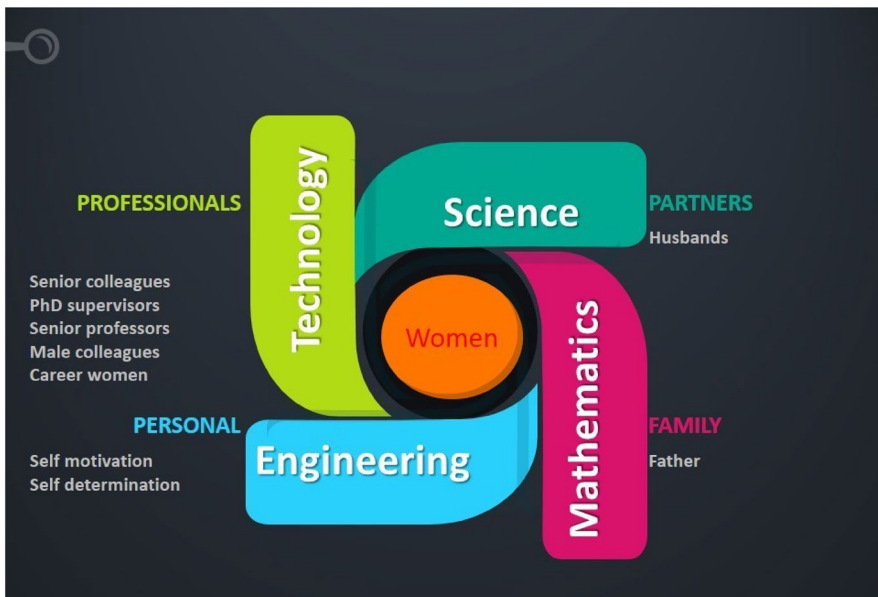
My journey was challenging, but I have learned to struggle to pass through difficult nodes (P34/Sudan/45-54)

First believe in me and then in my family (P35/Sudan/55-64)

The whole preceding is illustrated in Figure 2.

### Research Question 3: What does successful STEM leadership mean for women in STEM leadership positions?

Participants described the characteristics of an effective leader. A successful leader is characterized by the desire to find a scientific solution to a community problem and the pleasure of observing that solution. Although it can be difficult for men, successful leaders are creative problem solvers who can identify alternative solutions. This leader must also be proactive, pursue goals despite all obstacles, and effectively mentor younger members. She must be resourceful and adept at navigating demanding situations; she must also be a skilled negotiator worthy of emulation. Additional requirements include the design and execution of context-specific problem-solving research according to international standards, the



**Figure 2** Sources of inspiration for women in STEM leadership journey: Senior professors, senior colleagues (male and female), husbands, Ph.D. supervisors, and the personal self-stand out as sources of inspiration for women in their STEM leadership journeys. *Source* This work



production of required results, the sustainability of the products, and the development of capacities, thus advancing the system to a higher level.

When results of anticipated objectives are realized (P48/Uganda/35-44), A successful leader should be able to embrace diversity (cultural and religion) without bias, through networking, being creative, and being a good negotiator. They must be determined and focused on achieving the objectives of the organization. I am open to new ideas and listening to others while encouraging teamwork and allowing others to do their work (P2/Malawi/45-54)

The person qualified to manage a group positively pushes and motivates the members to achieve a defined goal. I possess soft skills such as generosity, kindness, gratitude, and empathy; I am also a good listener and intelligent enough to be an effective leader. I can make a mistake, but that is what I think (P40/Cameroun/35-44).

Being determined to produce the required results, making the results sustainable and building capacities despite all challenges and still able to mentor young people successfully (P7/Nigeria/35-44)

These excerpts confirmed that a leader's qualities are thriving in an organization. Leaders must collaborate with individuals of diverse backgrounds (culture, race, and religion). Additionally, leaders must have exceptional communication skills. Therefore, they must be receptive to innovative ideas and employ communication strategies to encourage teamwork. It also showed that leaders influence their workforce, so genuine leaders must have followers. It is confirmed by the excerpt from the participants presented in the following.

Successful leadership in STEM is when followers cooperate with the leader, and the leader, on the other hand, inspires the followers to achieve greater heights. For this reason, successful leadership is indicated by the willingness of workers to perform their work efficiently and effectively without being coerced (P25/Nigeria/65-74)

They must be visionary, determined, and focused on attaining the organization's goals, sticking to one objective, and aiming to achieve it within a stipulated time frame. The leader should allow those in the department to work freely and produce results. Similarly, successful leadership in STEM is the ability to coordinate, harness resources to achieve set goals, and deliver on my mandate within the stipulated time and in the right way (P20/Nigeria/35-44).

Another participant described a woman leader's success thus as follows:

Successful leadership is the ability to generally lead others to success in career and life and make followers successful. She has risen through the ranks and reached the peak of her career. Such a leader should be knowledgeable and at the same time open minded to new ideas and encourages collective decision-making (P21/Kenya/35-44)

On the contrary, another participant asserted:

As a leader, one should be a mentor, a motivator, and a pacesetter for followers. She should be ready to mentor, pass on the mantle to the next leader, be good at networking, and guide and support young scholars in mathematics. Successful leadership in STEM can also reproduce her in bringing up other young students (especially females) who look up to you for guidance while being focused and productive. It is also the ability to impact the lives of the growing network and to help them make meaning of their lives (P22/Kenya/45-54). STEM is becoming the most important area that feeds the collaboration of science and technology. Therefore, successful leadership in STEM will enhance women's efforts toward development (P34/Sudan/45-54).

#### Research Question 4: What qualities do women need to be active STEM leaders?

Several participants believed that their faith in God gives them confidence and determination to achieve most of what they achieved with the resulting grace. Other respondents attribute it to individual perseverance, teamwork, resilience, diligence, people skills, and neighborliness. Work ethic, democracy, authenticity, originality, investment in a peer network, and being a builder are essential qualities of an effective leader. Other qualities include being attentive, efficient, leading by example, impartiality, sufficient time, task resources, and self-management. Additionally, there are excellent communication skills, listening to other perspectives, identifying and using resources, an open mind, and excellent negotiation abilities. Strong networking skills, a can-do attitude, tenacity to follow through regardless of the time required, commitment, courage, and willingness to accept challenges may be required, particularly when researching rugged terrain. Figure 3 pictorially captures this.

In addition, the list includes a strong will, determination to succeed, refusal to be discouraged, respecting others' opinions, listening and implementing valuable



**Figure 3** Characteristics of an effective leader in STEM *Source* This work

suggestions, inspiring colleagues to strive for more incredible accomplishments, and patience. A participant supported the claims previously stated by stating:

Undoubtedly, the ability to assume multiple roles and think in interdisciplinary research contributes to becoming an effective leader in STEM. These include honesty, fairness, and the courage to ask anything, even if it is uncomfortable for other colleagues. They are creative in terms of ergonomics and function, making the office lively, displaying social intelligence, and allowing freedom of exercising individual initiative within some limits (P13/South Africa/45-54).

In summary, the respondents emphasized humility, love, being conscientious and steadfast in whatever one undertakes, self-discipline, setting goals, and diligently pursuing. The characteristics of prioritized goals, current, social, and tenacious are required.

Knowledge gain application, research performance application, and collaborations with the other interdisciplinary approaches (P34/Sudan/45-54).

### **Values and strategies appear in women's STEM leadership roles**

The participants emphasized that their values and objectives are valued in daily departmental operations and in delegating responsibilities to others. Maintain excellent communication skills, demonstrate respect, lead by example, discern the motivations of various individuals, demonstrate patience, be attentive, and respect diversity. Women mentioned filters, growth, self-actualization, the self-esteem of others, and self-esteem as advantages.

One participant stated that the responses to mentorship and follow-up they have received so far had deepened their commitment not only to their research and career but also to their private life and family. Other value-driven factors include merit-based resources, positive teamwork partners, positive supervisor attitude and behavior, and encouragement from future researchers to mentorship. In addition to financial and interpersonal honesty, additional values, goals, and strategies include positive attitudes toward the opinions of others and the sharing of responsibilities. Others said leadership roles manifest themselves in upholding integrity, being accountable, and sometimes taking tough, decisive decisions in colleagues' best interests. It also involved serving as a model for those under their authority. Specifically, some said:

The desire to achieve desired goals, both short-term and long-term, propels me to involve anyone likely to contribute in one way or another in the team. This strategy helps in the long run, as the synergistic effect of the team leads to faster and more result-oriented achievements. In doing so, members become empowered, potentials are released, and innovations and inventions are created. Similarly, the system and its environment become sensitized. Moreover, the organization becomes advanced, progressive, and eventually impact gains recognition from higher authorities (P10/Nigeria/55-64).

## Discussion

This study focused on the career paths women in leadership pursue to achieve success despite gender perception, especially in Africa, in STEM-related fields. The findings showed a contrary view that women leaders in STEM were incompetent and failed (Ebert et al., 2014) and that organizational inequalities affect women's career paths (Kirton & Robertson, 2018). These findings support the theory of social cognitive career as articulated by Lent et al. (1994), Liu et al. (2014), and Turner et al. (2019) that career development is influenced by personal, experiential, and learning factors. Although there are still challenges, as explained by a participant, a male classmate's bullying was responsible for her inability to study and comprehend mathematics. The blame for this behavior has been laid on the path of authority to address the issues that threaten women's career advancement (Griffiths & Moore, 2010).

Women's career advancement has been achieved through scholarship, personal effort, and motivation. It confirms the claim of self-sacrifice (Arnold & Loughlin, 2010) and that people develop best when they supervise their development (Petrie, 2014). Women's career paths and advancements, particularly in academia, result from individual productivity, particularly in publication (Lerchenmueller & Sorenson, 2018). Thus, achieving a leadership position means that individuals must be involved in paper publications, attend conferences and workshops, and be a member of a learned society, which includes social scientific networks. Therefore, it requires a lot of perseverance, self-determination, personal effort, dedication, and effort. Some participants cited some of these points as responsible for their career advancement and success in a leadership position.

Contextual structural barriers that hinder career advancement were identified as family, including raising children, pregnancy, and the structure of marriage, which are socio-cultural factors that affect career progression. According to (Wilkins-Yel et al., 2022), these could cause psychological distress. For example, a participant had to defer her admissions twice to pursue post-graduate programs due to pregnancy. However, these factors can ease the psychological burden of contextual barriers in STEM leadership with the right advisors, peers, professors, and significant others. Studies by Lee et al. (2015) and Navarro et al. (2014) support this.

Similarly, Erdreich (2016) observed that student career paths led to career advancement after university education. The family structure was also a significant factor in determining the career path of those who returned home after completing tertiary education. The socio-cultural factors issue agrees with the narrations of some women participants. However, some participants noted balancing career and family responsibilities, primarily women.

The literature identifies the quest for self-discovery and independence in sustaining women's career paths. It is attested to research by Benavent et al. (2020) and NRC (2012). Erdreich (2016) asserted that university education experiences and transformation distinguish educated women from uneducated women. These experiences and university education, especially in STEM vocational education,

changed their ideologies and continued to identify with them, thus defining their career paths. It also agrees with the response that their doctoral education has served as a stepping stone and distinguishes them from their peers. Christensen et al. (2014) found that those interested in STEM aspire to collaborate with more STEM professionals than their peers. Encouragement from STEM professionals refined the career path. A respondent reported that the comment of “a lecturer” following a group work presentation by her encouraged her to pursue a master’s degree and subsequently became a lecturer in the same institution.

As career individuals are rooted in social relationships, career success can function as perceived social support (spouse and workforce support). Some participants were inspired by their spouses; this is consistent with Ocampo et al.’s (2018) findings, which described mid-career as a life and work crisis with family and work obligations. Furthermore, Palumbo (2016) research highlighted the importance of information and guidance in encouraging female graduates’ employment. It may involve providing credible information that dispels prejudices against women’s career employment. As stated by a participant, current findings confirm the possibility of information bias in recruiting and promoting women to leadership positions.

The low participation of women in STEM-related fields can be attributed to motivation, which can be traced back to school and family (Ceci et al., 2009). However, some participants mentioned that their fathers or spouses influenced their decision to pursue a STEM field. Mentorship, leadership training, and support systems must prepare women for leadership positions as professors, department heads, and directors. According to Zacharatos et al. (2000), parental modeling influences leadership development based on social learning theory. In this case, women STEM leaders in Africa start their leadership development at a younger age. They are shaped by parental modeling, as alluded to by Zacharatos et al. (2000). The design of STEM instruction was motivational and influential (Aeschlimann et al., 2016). Instructional motivation in STEM includes knowledge about career opportunities. The current research result agrees with these observations, as participants indicated that post-graduate supervisors inspired their leadership journey. The findings confirm that social capital influences leadership development (Bilhuber Galli & Müller-Stewens, 2012).

Identify factors such as male ego, disobedience, and family responsibilities that make career and guidance difficult for women. The study by Vial et al. (2016) revealed that there are challenging times in leadership positions; however, women experienced more of this challenge than men. However, from this study, it could be observed that exceptional leadership was a necessary factor in STEM women’s success. Exemplary implies that leaders must exhibit charisma and pragmatism (Griffith et al., 2015), which the participants attested to. As the psychological makeup of each leader is unique, women leaders employ various emotional strategies to influence their followers. The research of Çekmecelioğlu and Özbağ (2016) confirmed that successful women leaders intellectually influence their followers; therefore, they inspire their followers’ creativity. Participants noted that a true leader commands followers to perform assigned tasks and take the necessary actions.

The data collected indicated that successful women leaders have empathy for their subordinates. Thus, eliminating suspicions of favoritism and demonstrating

integrity when dealing with all categories of employees. A characteristic behavior like this enables women to serve as great leaders in the workplace. As the participants mentioned, a leader has to be democratic. To be democratic, a leader must manage stress and accept the opinions of others. These assertions were supported by recent research (Mayer et al., 2017). The behavior of STEM leaders appears to inspire their followers to align their interests with those of the organization, which is consistent with the African value of shared community relationships and the desire to associate effective leadership with honesty and integrity (Galperin et al., 2017), as evidenced by the study findings. Leadership characteristics include encouraging subordinates, listening to other people's suggestions, and leading by example. Holmes' (2005) research confirms that behavior modeling and responsibilities distribution assist a mentee's growth and response to career enhancement with a gender-appropriate mentor that is remarkably flexible stylistically. Furthermore, this leadership behavior supports the invocation of healthy work cultures, as advanced by Ardichvili et al. (2016).

Women's leadership values are more relational, community-oriented (Fritz & Van Knippenberg, 2017), and mediated (Richardson & Loubier, 2008). No wonder Marchiondo et al. (2015) described leadership as an interpersonal relational construct, which agrees with the Women in STEM leaders' contention that leadership is a relational issue that requires humility, firmness, outspokenness, and teamwork, among other features. A leader's self-awareness is essential for successful leadership (Taylor et al., 2016). Therefore, leaders must improve their accuracy in predicting positive workplace behavior, which is crucial for leadership capability instruments and leadership success. These are supported by the research finding that if one is aware of the inherent challenges in the system, one would not be destabilized when such arise. The current outcome is coherent with Patel and Buiting's (2013) study, which indicated that increasing numbers of board members increase thinking style in shaping and affecting leadership style.

### **Practical and research implications**

Through this study, it has been proven in practice that the success rates of African women in STEM leadership are due to their collective achievement, thus dispelling the myth that they may not perform in STEM leadership. The current study has opened up a way of advancing toward the equitable representation of leadership roles in STEM work cultural environments; more women will have the opportunity to benefit and learn about these women's leadership success and how they overcame obstacles in that field. Academics, research organizations, and those working beyond the current field of study can conduct more research on the attitudes and behaviors of STEM women in leadership positions in Africa, with a more focused sample between genders that could produce more intriguing findings. Hopefully, this work will lead to other conversations that demand intellectual growth.

The study revealed a commonality in the tone and life experiences of African women STEM leaders tone and life experiences; due to the sense of community in Ubuntu, all women shared a passion for STEM (Lituchy et al., 2017; Poltera &

Schreiner, 2019). STEM education should be sustained to produce points of view, curriculum, and instructional efforts. Therefore, comprehensive vocational education should be a must to close the gender gap for women in STEM. It also implies that comprehensive vocational education should be designed to bridge the gender gap, especially between young girls, to encourage girls' interest in science. Last but not least, efforts must be made to stimulate conversations about the successful implementation of survival strategies for future STEM leaders in the workplace. Such policy programs will help move closer to the sustainable development goal of equity, diversity, and girls' education, as the General Assembly (2020) elaborated.

## Limitations

Due to geographically dispersed locations on the African continent, conducting interviews with the sample group was impossible. Some African countries were inaccessible, and potential participants were unwilling to participate voluntarily. Formal interviews conducted during the research would have resulted in a more in-depth understanding of STEM women's perspectives and responsive abilities as probing would have led to deeper insights.

## Conclusion

This study concludes that successful leadership involves more than just holding a position; it also involves resolving community issues and mentoring aspiring scientists. This study derived data from participants ('field texts') on African women's STEM leadership behavior. Data were examined for emerging codes, themes, and patterns, and the existing literature was discussed. Qualitative research is best suited to studying microphenomena as it provides helpful information on how individuals internally navigate the identities of asymmetries at work.

Successful STEM leadership involves balancing a career with family life, setting goals, solving problems, being receptive to innovative ideas, embracing diversity, collaborating, possessing STEM research expertise, and mentoring skills. In this study, most STEM organizations come from higher education institutions. The level of education contributed to the achievement of women's leadership positions. Scholarships, a reassuring organizational structure, dedication, hard work, and perseverance were credited with facilitating their career paths. Senior colleagues (male and female), spouses, post-graduate supervisors, and yourself are notable sources of motivation for a journey into STEM leadership. A successful woman leader must balance her professional and familial responsibilities as she pursues STEM careers.

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## Declarations

**Competing interests** The authors declare no competing interests.

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