Closing the Mathematical Gender Gap in Higher Education: A Case of Graduate Female Students in the Kenyan Universities

Women’s representation in mathematics and sciences remain below 30% at the doctoral level globally. Yet, non-discriminatory education, especially in mathematical sciences will enhance the achievement of the Sustainable Development Goals (SDGs) and Vision 2030. However, a few women have succeeded in graduate mathematics. This study examined the personal and institutional experiences that influenced the success of women in graduate mathematics. Purposive and snowballing approaches were applied to select five female graduate students and five female math faculty in three selected university (public 2, private 1) mathematical science departments in Kenya. Data obtained through interviews were thematically analyzed. The findings revealed that interest in math was developed at the primary and high school levels; encouragement from math teachers, parents, and female faculty; overlooking the math-gender stereotypes, commitment, balancing between work and academics, mentorship and provision of a supportive environment at the department enhanced their success. To close the mathematical gender gap in higher education, female students should disregard the gender stereotypes, work hard, and develop a positive attitude towards math. Similarly, math departments should develop a critical mass of female math students and female faculty and provide a supportive environment. Further, gender-based policies should be initiated to increase women mathematics.

Keywords: Women, Mathematics, Gender gap, Female students, Math barriers.

Introduction

The problem of female underrepresentation in mathematics and science related fields has been an ongoing concern despite the societies’ efforts to facilitate the process for women to hold “male-dominated” jobs (Ceci & Williams, 2011; Wang et al. 2013). Thus, “gender gap”, which is often termed as inequality or inequity has always been of interest, not only in educational research, but also from a political and economic context (UNESCO 2015a). For instance, one of the Sustainable Development Goals (SDG-5) focuses on the achievement of gender equality and empowerment of women and girls.

Over the years, women have hardly pursued and enjoyed mathematical endeavors. Majority of the women prefer taking the path of humanities and social sciences. Currently, there is a large imbalance in the participation of women in mathematics compared with the participation of men, at the graduate school. Globally, women are under-represented not at the entry into mathematics education (primary education) but starting in graduate studies due to a “leaky pipe” of career development. According to the National Science Board (2018), gender participation varies across educational levels. As women
advance in their education, they ‘leak out’ of the mathematical pipeline. They
either drop out or are pushed out of mathematical pipeline at different levels of
education. Thus, the number of women in math reduces as they advance in
their education. For instance, in sub-Saharan Africa, girls are pushed out of
Science, Technology, Engineering, and Mathematics (STEM) fields due to
cultural practices, mathematics stereotypes, societal and institutional attitude
towards math, biased teaching and learning materials. In most cases women
lack encouragement to participate in mathematics at the graduate level.

Statement of the Problem

Graduate school is supposed to produce highly qualified mathematicians
for the labor market, especially in the science related fields (Altbach, 2005).
Given that mathematics is a critical component of the school curriculum, an
enabling discipline for the stem fields, and an important gateway to adult life
and occupational opportunities (OECD 2013), the participation of both males
and females in mathematics at the graduate level is fundamental. Conversely,
low participation of women in mathematics will limit their chances of
contributing to the global social and economic development. While increased
participation and success of women in mathematics will lead to increased
participation in the existing and future related careers and opportunities.
Regrettably, mathematics has traditionally and continues to be a male-
dominated field. Yet, changes in the global economy and in technology require
mathematical literacy.

In the Kenyan context, efforts to increase the number of women in
mathematics have been put in place—the Kenya’s Gender Policy in Education,
(Republic of Kenya, 2007); Kenya Women in Mathematical Sciences
Association (KWIMSA) registered in 2014, African Women in Mathematics
Association (AWMA) created in 2013; Annual Scientific Camps of Excellence
for Mentoring Girls in the STEM fields organized by the UNESCO Nairobi
Office, together with the Government of Kenya, the National Commission for
Science, Technology and Innovation, and the University of Nairobi; basic and
higher education policies—yet gender disparities in mathematics are eminent,
especially at the doctoral level. Thus, Hurtado (2021, 12 March), argues that
there is a “heavy under-representation” of women in the STEM fields globally.
Conversely, there are a few cases (30%) of women who have succeeded in
mathematics up to the graduate level globally. This study focused on the
experiences and practices that have enabled women to succeed in graduate
mathematics. The success stories of these women are likely to influence other
women who may have been socialized to believe that math is for men to come
out and study math up to the graduate level. This will also enable policy
makers initiate gender-based policies to encourage women to participate in
math, hence close the mathematical gender gap in higher education.
Purpose and Objectives of the Study

The purpose of this study was to establish the factors that influenced the female graduate students to choose and pursue mathematics up to graduate level. The specific objectives were to: (1) find out how and when the graduate female students started to develop interest in mathematics; (2) establish what motivated female graduate students and female math faculty pursue mathematics up to the graduate level; (3) determine the challenges female graduate students faced, how they responded to the challenges they faced in a mathematical environment, and how the female math faculty assisted them handle those challenges; (4) examine the lessons female graduate students learned from doing graduate mathematics.

Theoretical Framework and Conceptualization of the Study

The study was guided by the Control-value theory (Pekrun, 2006) of achievement emotions. The theory provides an integrative framework for analyzing the qualifications and effects of emotions experienced in achievement and academic settings. It is based on the premise that appraisals of control and values are fundamental to the encouragement of achievement emotions, including activity-related emotions such as enjoyment, frustration, and boredom experienced at learning, as well as outcome emotions such as joy, hope, pride, anxiety, hopelessness, shame, and anger relating to success or failure. Effects of the theory relate to the effects on engagement and achievement across genders and cultures. The representation/under-representation of women in math at the graduate mathematics correlates with this theory; their success is mainly tagged to their encouragement of achievement emotions. Given that traditionally mathematics has always been associated with the male domain; venturing and succeeding in this male domain, at the graduate level, the female’s achievement emotions must be triggered both internally and externally. Thus, Pekrun’s theory (2006) supports Henrion’s (1997) argument that once the desire for mathematics is triggered, it needs to be reinforced by the mathematics community to create a sense of belonging in the student.

The conceptualization of the study hinges on the principle that the success of women in graduate mathematics is influenced, among others, by personal interest, intrinsic and extrinsic motivation, and responses to the challenges experienced in the mathematics environment. Students who enjoy mathematics are assumed to focus their attention on the tasks, making better use of deep learning strategies and, therefore, getting better results. According to Rodriguez et al, (2020), motivational and emotional variables, which involve beliefs, interest, anxiety, emotions, and attitudes, perceived competence and self-efficacy are associated with achievement in mathematics. On the contrary, students who are bored in mathematics classes pay less attention and make less
use of learning strategies or use more artificial strategies, which leads to lower achievement (Putwain et al., 2018), hence drop out of the mathematics pipeline.

Related Literature

The underrepresentation and poor performance of women in math is associated with the belief that women do not have the ability to do math. This assumption has had the effect of causing uneasiness among girls and thus lowering their performance in mathematics (Spencer, Steele & Quinn, 1999). In contrast, positive emotions towards mathematics, according to the principles of control-value theory, could have effect on girls’ dedication (Pinxten et al., 2014).

In the U.S., stereotype threat has been linked among women at large public universities to worse performance on mathematics tasks. Stereotype threat has also been linked to decreased interest and persistence in the STEM fields (Woodcock, 2012; Shapiro & Williams, 2012). Similarly, in Tanzania, girls’ underrepresentation in math have been associated with gender stereotypes of mathematicians and math-related professions as “masculine”, and a belief that girls and women are not as capable in the STEM fields, unfavorable classroom environments and interactions, pedagogy, curriculum and resources, assessment practices, lack of informed career guidance encouraging girls to pursue studies in the area of mathematics, and lack of confidence and motivation to excel in and pursue mathematics (Asimeng-Boahene, 2006; Masanja, 2010; Zilimu, 2014). Studies (Cvencek, Meltzoff, & Greenwald, 2011), reveal that girls possess a weaker self-identification with math than do boys, and thus a lower achievement level than boys. According to Herzig (2002) the mathematical environment—feelings of isolation due to too little contact between faculty and students—discourages women from participating in mathematics programs.

A study (Ongiti, 2014), carried out in Kenya among high school girls on the impact of the mathematical gender stereotype revealed that: 94% of girls disliked math because they believed it is hard for them; 77% had a negative attitude towards math; 54% indicated that math is for boys; while 40% believed that they cannot do math. As a result, girls perform poorly in math and eventually drop out of math in high school, which translates to few women persisting in math up to the university level; hence under representation of women in graduate mathematics.

Ineffective pedagogical practices have been cited as influencing low participation of girls in math. Nerad and Cerny (1993) argue that students in departments with impersonal environments that do not provide professional support to students are more likely to leave. Similarly, Masanja (2010, p. 5), argues that social cultural beliefs and practices and the way teachers treat girls in classrooms, especially mathematics and science classrooms impact learning experiences.
According to the role model theory of Davies et al. (1996), too few role models, and the perception that access to career opportunities and salaries are limited, discourage women from enrolling in mathematics. While according to Cooper (2000) encouragement and moral support from mentors in graduate school plays an important role in student’s decision to enroll and persist in graduate studies in mathematics. Besides, lack of career guidance, counseling, and role models inhibit women and girls from pursuing math at higher levels of education. This situation has a negative impact on girls’ uptake of the STEM subjects (Asimeng-Boaheme, 2006; Nancy, 1999). So, girls find it difficult to establish a future identity in the STEM fields without role models. Studies (Carrell, Page, & West, 2010; Bettinger & Long, 2005) have found that female professors have a positive effect on the performance of female undergraduates. The extremely low proportion of female faculty members perpetuates the gender gap in mathematics. Ongiti’s (2009) study revealed that female graduate faculty acted as role models for the success of female graduate students in math.

Lack of confidence in their mathematical abilities, the attitude/belief that girls are inferior to boys in terms of their mathematics, their classroom experiences, and the messages they internalized about their roles, their futures and their capabilities are associated with the underrepresentation of women in math (Dahlborm et al., 2010; Jakobsson, 2013). Likewise, math anxiety and poor performance are correlated (Poursoslemi et al, 2013). Yet, the formation of a peer group reduced student stress and supported students in coping with the challenges experienced in math at the graduate level (Ongiti, 2009).

Nonetheless, a study by Ongiti (2009), on the professional socialization of women in graduate math, conducted in the U.S. women succeed in graduate math due to, among others, the departmental supportive environment, having an open-door policy by faculty, being treated as faculty in the making, encouragement from faculty and female role models, flexibility of policies to accommodate them, pedagogical approach, critical mass of female graduate students at the math department, hard work and developing a sense of belonging in the math department and the mathematical society.

Given that this study focused on the experiences and practices that made women succeed in graduate math in Kenya, this study sought to answer the following questions: (1). When and how did these women develop interest in math? (2). What motivated them to study math up to graduate level? (3). What are some of the challenges they face as they pursue math at the graduate level? how do they handle those challenges? How do the women faculty assist female graduate students handle the challenges they face? Finally, (4). What lessons have these female graduate students learned from pursuing math up to the graduate level?
Methodology

This study, which was conducted in 2018-2019, involved three universities (2 public; 1 private) located in Nairobi County, Kenya and ten participants (5 female students, 5 female faculty). A qualitative approach through individual face-to-face interviews was applied to collect and analyze data. The study targeted female graduate students (at the masters and doctoral level) and female faculty teaching mathematics at the graduate level. Purposive and snowballing approaches were applied to select the three mathematical sciences departments, female graduate students and female faculty. A total of 5 female graduate students (from private university, none from public university because of unavailability), and 5 female faculty (3 from private university, 2 from public universities) participated in the study through face-to-face interviews. Majority (99%) of the female graduate students that participated in this study were mature students, married with families, and working at the same time. They also had other social responsibilities.

The five female graduate students (Student-DW1, Student-SR2, Student-MG3, Student-EM4, Student-JM5) participated in the interviews. All the five students were from one private university. The first student (Student-DW1) was in her second-year master’s program. The second student (Student-SR2) was doing her master’s degree and was in her final year. The third student (Student-MG3) was a PhD student in second year. The fourth student (Student-EM4) was in her third year. The fifth student (Student-JM5), was a PhD student in applied mathematics in her third year.

The female faculty (Faculty-AG1, Faculty-HE2, Faculty-WI3, Faculty-WA4, Faculty-GR5) were currently teaching mathematics in the three universities. Both students and faculty participated in the face-to-face interviews took place in the faculty offices, while that of the students was conducted in one of the classrooms, at different times. The interviews lasted between 45 minutes to one hour. Interviews were tape-recorded after getting consent from the participants. Recorded data were transcribed, summarized and analyzed based on the assigned codes and themes from the four research objectives. Qualitative data was analyzed separately (starting with students, then faculty) and then combined to determine the major findings.

Results

Qualitative data were collected from female graduate students and female faculty; hence analyzed based on the four main themes: (1) When and how female graduate students developed interest in mathematics; (2) Female students’ motivation to pursue mathematics up to graduate level; (3) Challenges female students experienced in a mathematical environment and how they were handled by both students and female faculty; (4) Lessons female graduate students learned from doing graduate mathematics.
Theme 1: When and how female graduate students developed interest in mathematics

Under this theme female graduate students were asked to explain how they developed interest in mathematics, at what level and what motivated them to do math. Female faculty teaching graduate mathematics were asked how they ensure that the women in their class are motivated to persist in mathematics.

Responses from female graduate students

The findings revealed that most (60%) female graduate students started liking math in primary and high school. This is revealed in the following statements: “Actually my liking for mathematics basically was actually triggered off by my mathematics teacher in form two” (Student-DW1). “I personally like mathematics all the way from primary when I was in primary” (Student-SR2). “Well my motivation dates back to secondary school” (Student-EM4).

Mathematics teacher in high school influenced majority (60%) of the students to develop interest in mathematics:

Well my motivation dates to secondary school. I was motivated by a teacher who was also doing PhD in mathematics, he saw potential in me although at that time I wasn’t very good in mathematics but he kept on encouraging me to study mathematics to do a lot of practice, from that time I got some interest in mathematics (Student-EM4).

Parents, especially fathers, were cited to have played a significant role in motivating women to do math. For instance, one of the student’s states:

My parents also especially my Dad also…so all through my dad used to tell me I look like a man so I should be doing mathematics…Yes…you can do well in mathematics and even when I got the results home, he was like mathematics…I am interested in mathematics if I fail in English, he didn’t mind but in mathematics he really minded. (Student-DW1)

Although the parent was encouraging his daughter to pursue mathematics because he looked like a man, the daughter did not get offended, instead she got encouraged and pursued mathematics up to graduate level.

Personal liking for math: majority (80%) of the female students pursued mathematics because they had a personal liking for mathematics right from primary school. They simply loved math.

I personally like mathematics all the way from primary when I was in primary my teacher was very strict and if I didn’t have that motivation I was going to lose hope because most of those whom we were studying together lost hope because the teacher was very strict… But I was motivated because I liked mathematics because I knew it was first of all in my family many people liked mathematics.
that is their area of success and I knew that is the area that I wanted to pursue
(Student-SR₂)

Right from when I was very young I felt deep down I have a love for
mathematics… well I loved the math …I had some love for math which was not
very well natured so I think I would say in primary school I performed on average
I was slightly above average…I wanted to do mathematics from whichever level
whether certificate or whatever, but I just wanted to pursue mathematics that was
what was in my heart. (Student-JM₃)

…when I went to university I just chose to do mathematics because I felt that it is
the easiest compared to other sciences because mathematic you don’t have to read
so much taking notes and all that so I took that side because I knew the it was
only about knowing the formula and studying then you are good to go so I felt it
was easier compared to the others which need a lot of cramming… (Student-
EM₄)

Likewise, Student-MG₃ stated: “I will say from school back in high school I
liked mathematics”

From the above responses it is revealed that female graduate students
started developing interest in mathematics from high schools and even primary
due to the influence of mathematics teacher in high school. Parents, especially
fathers, were cited to have played a significant role in motivating their
daughters to do mathematics. Also, encouragement from family members who
liked mathematics, and personal liking for mathematics, and the love for
mathematics motivated women to develop interest in math.

Responses from female faculty were as follows:

Female faculty teaching graduate mathematics were asked how they
ensure that the women in their class are motivated to persist in mathematics.
The following are some of the responses:

Encouragement and motivation: “Encouraging them to do mathematics
and ensuring the teaching methods are simple and friendly” (Faculty-AG₁).
“Creating room for consultation in case of need. (Faculty-HE₂)

when I am teaching I do not want to look like women there is a weak link or there
are some weaknesses in women, I put it in a level ground like it is a subject like
any other, you have committed up to a postgraduate, you have committed to do
the subject, so move to whatever it takes before you consider you are a woman.
Take the subject first and then the gender comes second…my mode of delivery
speaks itself in the sense that I treat the students equal. Not showing like men can
understand more than women and we commit to the subject at level ground.
(Faculty-WA₄)

In most cases we as a university, there is no program where we say we are
motivating the students. It is only us as the female lecturers in one way or another
we try to talk to our students… especially for female students is just by
counselling (Faculty-GR₅)

Role model: According to Faculty-HE₂, “being their role model and by
rewarding and recognizing their presence when dealing with mathematics”

Another faculty member stated that Individualized attention to female graduate
students plays a role in their retention in mathematics:
I have a one on one contact with the students from the beginning, I do personal
follow up for the students’ right from the time they came to university until the
time they leave university. And give them the necessary guidance and mentorship
that will help them progress well in a very competitive field of math. (Faculty-
WI)

Theme 2: Female students’ motivation to pursue mathematics up to
graduate level

In response to this theme, female graduate students stated the following:

Mathematics is the easiest subject compared to other sciences:

...when I went to university I just chose to do mathematics because I felt that it is
the easiest compared to other sciences because in mathematics you don’t have to
read so much taking notes and all that; so I took that side because I knew that it
was only about knowing the formula and studying then you are good to go; so I
felt it was easier compared to the others which need a lot of cramming...
(Student-EM)

After I finished my masters in administration I was offered a chance for PhD in
administration and arts at Kenyatta university, but I turned the offer down, I was
like me, I am not ready for more stories; do you know mathematics’ it is specific
and you don’t need to cram so many things once you understand the concept you
just get going so long as the concepts are well presented. (Student-DW)

Being good in mathematics: it was also revealed that some female graduate
student was good in math right from high school, therefore they had good
foundation, which enabled them to continue with math at the graduate level:

I started from high school, I scored an A and I was given a certificate...by then it
was district...I was among the top 5 in the district. Then coming to university all
my units almost all of them I scored an A so that is what made me to pursue
masters because I saw it is something that can be done unlike what other people
were saying... if I scored an A then it is possible. (Student-SR)

One of the students pursued math at the graduate level to proof to other
women that women can also do math

... I have seen many ladies they don’t like mathematics that is what has
motivated me...I wanted to do it and see it as something that can be done...it is
not difficult. So, I wanted to venture into deeper mathematics because many
ladies fear mathematics...so that is what motivated me I wanted to do more so
that I can see whether it is the way they are saying or is it not. (Student-SR)

Self-motivation and forming groups were some of the other factors that
influenced women to pursue math up to the graduate level:

Having taught now math for 10 years I felt I can do it...I can try mathematics
undergraduate. That’s when I came and did double math then I realized ooh so
it’s working. I remember we used to work...we formed groups and we were three
of us my friend currently she already graduated here at catholic university with a
PhD (Student-MG₃)

The love for math motivated some female students to pursue math up to
graduate level:

I remember when I was called to the university I was called to KU to do
language, education language and I still felt that love for mathematics I would
still feel no something is wrong somewhere but my heart is in mathematics
however much I was not doing so well but I could still feel I had that love.. I
wanted to do mathematics from whichever level whether certificate or whatever
but I just wanted to pursue mathematics that was what was in my heart...so for
sure I got admission to Kenya Science Teachers College (KSTC) then and that is
when now my journey with mathematics began (Student-JM₃)

Theme 3: Challenges female students experience in a mathematical
environment and how they were handled by both students and female
faculty

The study revealed that, among the greatest challenges female graduate
students faced in a graduate mathematical environment was balancing family,
schoolwork and employment. To mitigate against this challenge, some of them
formed groups to enhance commitment to academic work.

I am a mother of several children, a wife of course working being a student is not
very easy and especially as a PhD student… for me the biggest challenge has
been trying to combine the three: family, career I mean …work the
profession...studies it has not been very easy. (Student-JM₃)

The challenges I have faced myself is the issue of time and balancing family, love
and school and work. Yes, I am working and a mother of standard four...so you
know standard four aamuke aende¹, ...I am studying. And I am also a wife. I am
also involved in church… (Student-DW₁)

When graduate female faculty were asked the challenges their female
students face; the responses ranged from: faculty underrating them by looking
down upon them; gender bias and sexual harassment; lack of mentors;
balancing between work; family and school; to pedagogical issues. According
to Faculty-AG₁: “Some teachers underrate female students by looking down
upon them as they are not equal to task”. Other faculty members had these to
say:

Gender bias especially when they are told mathematics is not for girls. Sexual
harassment especially when they need assistance in mathematics, and they are
sexually harassed (FHE₂)

¹“Aamuke aende” meaning, to wake up and go.
Lack of mentors and the support that is necessary for them to progress well in the
field of math…sometimes you find that the ladies they are quite confined within
themselves that they are not willing to ask for assistance… lack of confidence. 
(Faculty-WI₁)

Yet Faculty-WA₄ stated: “Mostly those that are taking postgraduate courses are
family committed. So, you find women are tied with those other responsibilities
unlike the men they are learning with.”

One female graduate faculty stated:

Pedagogical issue was cited as one of the challenges women face, “We do just
like 30% or 35% and we leave the rest to the student to go and do research. You
realize that the concept of teaching, unless the student is very good in doing their
own studies, they have a problem of performance. (Faculty-GR₅)

When the female graduate faculty were asked how they assist female
graduate students handle the challenges they faced in the mathematical
environment; they responded as follows: “Encouraging and motivating all
students equally. Making mathematics easy and enjoyable. Being a good role
model” (Faculty-AG₁)

Also, Faculty-HE₂, stated:

Encourage them to have a positive attitude towards mathematics bearing in mind
that they can even do better in mathematics then men…educating them to say
“No” in case of sexual harassment when seeking assistance and report the case to
the authority…getting mentors in their area of specialization; having one-on-one
consultations; engaging them, being friendly and encouraging them motivated
female graduate students to cope with the challenges they experienced at the math
environment:

When students approach me in area different from mine, I make sure I get a good
mentor in their area of interest and make sure that I have a conversation with the
mentor on how the student is progressing and the advice that is necessary for
them to progress well in their particular area of interest… I am usually a bit
thorough because at the end of the semester I usually ask for their results and I go
through them step by step (Faculty-WI₃)

We engage them. If I notice, there is a problem I engage them. But more often
before you even notice they talk to you … I am a bit friendly to them and I keep
encouraging and giving them my story on how I did some of the courses up to
where I am. (Faculty-WA₄)

Similarly, Faculty-GR₅ stated that: “Performance wise I can’t say we do remedial
teaching. We try to advise, counsel and encourage them.”
Theme 4: Lessons female graduate students learned from doing graduate mathematics

When female graduate students were asked what they learned as graduate mathematics students in the mathematics environment, some of them learned that: life is all about mathematics; while others said that they learned that mathematics can be done; its applicable everywhere; yet some said that they learned patience because in math you must be patient with the calculation of numbers and this can be applied in life. One of the female students learned that she can be a role model, hence encourage other women to pursue math. After realizing that women can do math, she wanted to meet other women and tell them that mathematics is not hard; it is doable.

Yet another, female graduate student said that mathematics had taught her to be precise. In mathematics there are no two ways; one must be precise. Math also taught them how to critically think because in mathematics one needs a lot of critical thinking.

One, I have learnt that life…life is all about mathematics; waking up and trying to plan everything it is all mathematics right from the waking up… up to the sleeping it’s all about mathematics and planning. (Student-DW₁)

So I have learnt many things especially towards this last part that mathematics can be done…its applicable everywhere like what I am doing; I am doing about modeling of a disease and mathematics is coming in so I have come to learn that mathematics is just everywhere it can be applied anywhere. (Student-SR₂)

Out of that, I think what I have learnt is patience, I have learnt to be patient because for sure from 2011 to today those are several years if I did not have patience I would have dropped out (Student-JM₄)

Patience is one of the important things I have learnt that I must be patient I have to be focused despite the discouragements that have come along on my way… I can go back and be someone …pull up maybe …be an encouragement to the youngsters down there and tell them there is still hope…If I finish my studies I want to go back to the society and pull them up, I want to be a motivational speaker.” (Student-MG₃)

Discussion

The major findings are discussed based on the four foregoing themes: (1) Developing interest in mathematics: the findings revealed that female graduate students developed interest in math as early as primary and high school; they were influenced by their math teachers, had personal likings for math; and were encouraged by female math faculty who also acted as role models. The findings of this study support the role model theory of Davies et al. (1996) that too few role models discourage women from enrolling in mathematics, while many role models encourage women to participate in math. Also the findings
concur with Henrion’s (1997) argument that once the desire for mathematics is triggered, it needs to be reinforced by the mathematics community (in this case female math faculty) to create a sense of belonging in the student. The fact that these female graduate students had a personal liking for math, negates Ongiti’s (2014) study which revealed that 94% of high school girls disliked math because they believed it is hard for them and that math is for boys. However, this study supports Ongiti’s (2009) argument that female graduate students succeed in math due to having female math faculty as their role models. Therefore women can do math if they develop a positive attitude towards the subject and are encouraged by the ‘significant other’. The liking for math starts way back in primary and high school and is reinforced as one progresses to graduate level.

(2) **Motivation to pursue mathematics up to graduate level**: the findings under this theme revealed that female graduate students decided to pursue mathematics up to the graduate level because it was the easiest subject compared to other sciences; being good in math and the love for math; to proof to other women that women can do math; self-motivation; and forming groups. This study disapproves Ongiti’s (2014) findings where 77% of high school girls had a negative attitude towards math; 54% indicated that math is for boys; and 40% believed that they cannot do math. Yet in this study math is seen as the easiest subject and women are motivated to do math. The findings from theme 2 support Rodriguez et al, (2020); Pinxten et al. (2014); and Pekrun (2006) arguments that motivational and positive emotional variables are associated with achievement in mathematics. This study also supports the arguments of Dahlborm et al. (2010); and Jakobsson (2013) that lack of confidence in their mathematical abilities, the attitude/belief that girls are inferior to boys in terms of their mathematics, classroom experiences, internalized roles and their futures and their capabilities are associated with the underrepresentation of women in math, while self-confidence and achievement in mathematics are positively correlated.

(3) **Challenges female graduate students faced in a mathematical environment**: this study revealed that most female graduate students face the challenge of balancing family, work and academics; faculty underrate and look down upon them; gender bias and sexual harassment; lack of mentors and pedagogical issues. While students sought strategies to focus on their studies by forming groups, female faculty assisted these students to handle the challenges by: encouraging and motivating all students equally; making mathematics easy and enjoyable; being good role models; encouraging them to have a positive attitude towards mathematics; educating them to say “No” in case of sexual harassment when seeking assistance and report the case to the authority; getting mentors in their area of specialization; having one-on-one consultations; engaging students in the classroom and department; and being friendly. These findings build on Nerad and Cerny (1993) argument that students are likely to leave from departments with impersonal environments that do not provide professional support to them. Similarly, the findings of this study support the role model theory (Davies et al., 1996) that too few role
models, and the perception that access to career opportunities and salaries are limited, discourage women from enrolling in mathematics. The findings of this study also concur with Cooper’s (2000) argument that encouragement and moral support from mentors in graduate school play an important role in student’s decision to enroll and persist in graduate studies in mathematics. In addition, the current study supports Ongiti’s (2009) argument that the provision of a supportive environment to women attributed to their retention on the mathematics program at the graduate level.

(4) Lessons female graduate students learned from doing graduate mathematics: the major lessons learned were that math can be done by women; that life is all about math, therefore inevitable; math needs patience and this translates to being patient in life; and that graduate students can be role models to other girls, especially those in high school and encourage them to pursue math up to graduate level. These findings support the argument of Masanja (2010, p. 5), that girls have different approaches to learning math than boys and that they benefit from collaborative and cooperative learning approaches. Similarly, the findings of this study concur with Pinxten et al.’s (2014) position that positive emotions towards mathematics, based on the principles of control-value theory, could have effect on girls’ dedication.

Conclusion

The mathematical gender gap in higher education, especially at the graduate level is eminent across the globe. This study focused on women who have succeeded in graduate math from three universities in Nairobi. The study focused on their experiences and practices that enhanced their success and the lessons learned from the mathematical environment. The responses through interviews with five female graduate students and five female faculty teaching math at the graduate level revealed that the female graduate students started developing interest in math at the primary and high school; were encouraged and motivated by their math teachers, parents and female faculty; hence persisted in math to graduate level. These female students loved math and overlooked the gender stereotypes; they also wanted to prove that women can do math because they found math easier as compared to other science.

Given that most (90%) of the female graduate students were married and had family, balancing work, education and social work was a challenge. However, this challenge was addressed through the formation of peer groups. Besides, they experienced discrimination, gender bias and sexual harassment from male faculty. Even so, with the support from female faculty, provision of a supportive environment and encouragement female students persisted in graduate math.

Among the lessons learned from their experiences in the graduate math environment was that math was all about life; one cannot do away with math. That math can be done by women; it is not a male’s domain. What is needed in math is patience. That it takes time to be grounded in math. That the women
who have had a mathematical experience could encourage other women to pursue mathematics up to graduate level; hence act as role models. They also learned that taking graduate mathematics has taught some of them to be precise, develop critical thinking and overcome the gender stereotype threat. Thus, by sharing the success stories of women in math the mathematical gender gap will be minimized if not closed.

**Recommendations**

Based on the findings of this study that women can do math because they love math. Therefore, the Ministry of Education should come up with policies aimed at encouraging girls in the math pipeline right from primary school, high school to choose and persist in math to graduate level. So, emphasis on the women in the math ‘pipeline’ of basic and higher education to enhance the science-oriented labor force to meet the industry need of the future is essential. Early preparation of women in math (primary and secondary) is critical. The society (parents & significant others) and learning institutions should re-socialize women to develop confidence and have a positive attitude towards math.

Math departments and institutions should provide a supportive environment to enhance the retention and persistence of women in math. To attract more women in math at the graduate level, math departments should strive to develop a critical mass of women (both students and faculty) in math. Likewise, women faculty in math should act as role models (the push and pull model of women in math should be applied) right from primary to graduate level. The pedagogical approach should be flexible and sensitive to the learning process of women.

Given that the problem of women in mathematics still persist, all stakeholders (government, policy makers, researchers, business world, parents, students and the entire society) must be brought on board to rethink and realign alternative models to increase the participation and success of women in mathematics up to the graduate level and beyond.

Math departments (basic and higher education) should create a mentorship program to provide a diverse set of mentors – perhaps pairing graduate students, postdocs or other faculty members with undergraduates, high school and primary school. This allows women across all levels of education to receive a diverse set of advice and mentorship. This will provide more support and a more welcoming environment, as they will have someone to turn to for advice. Thus, closing the mathematical gender gap calls for a concerted effort by all stakeholders with diverse strategies including sharing the success stories of those that have managed to pursue math up to the graduate level as discussed in this study.
References


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