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"I Was Just Done With Calculations…. I Realized That I Like Working With People" Understanding Why Women Abandon Careers In Mathematics

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Abstract

Contemporary research on women and the learning of science in higher educational institutions has persistently focused on equal representation and access. This study sets out to find out why women, after successfully completing their degrees in mathematics at undergraduate and/or masters, quit the field. This is despite the popular view that the anticipated value of a career in mathematics to one's social- economic status cannot be under-estimated. This happens at a time most governments worldwide are committing more resources in education to encourage women to study mathematics and science. This paper reports interviews conducted among three women (from different countries in Sub-Saharan Africa) who studied mathematics at undergraduate and have since abandoned it to take on new careers in humanities and social sciences. The findings reveal that as women engage with mathematics at higher levels, their expectations and value of mathematics starts weathering off. Some develop the feeling that mathematics limits one's ability to interact with people as compared to other fields of social science such as management. More surprising findings revealed that relatives still play an instrumental role in discouraging women to pursue mathematics to higher levels.
Key words: women, gender, mathematics, career

1. Introduction

2. Background

The quest for women's position to be reviewed by nations in light of affirmative action and equal representation in social, economic and political spheres in Africa has its humble beginnings in colonial education, when western education was introduced. During this time, Allison et.al (2008) records that girls were not allowed the opportunity to attend school. Given that the purpose of education for colonial government was to prepare persons-mainly boys- to facilitate the running of the affairs of the colony (Masanja, 2010), the foundation of unequal representation in education along gender lines seem to have been established during this time. This is mainly because the inherent gender inequality in access to education in colonial Africa resulted from deeply rooted gender inequalities in Europe that were perpetrated by lack of gender equity policies in education at the time (Assié-Lumumba, 2006). This was in addition to gender discrimination that already existed within African traditional set ups (ibid.). For instance in Nigeria, education was introduced specifically for men to assist colonial administrators in managing the colony (Olujuwon, 2002) while in Kenya, university education aimed at fostering African 'male elites' who would play a pertinent but essentially subordinate role to the colonial administrators in perpetuating colonial policies and practices (Manya, p. 2002). The situation in Rwanda was even more disturbing: girls were introduced to western education more than thirty years after their male counterparts had been introduced (Masanja, 2010). From these experiences, colonial education in Africa favoured men and this practice left an indelible mark on the development of education in Africa on equal basis with regard to gender.

However, it was thought that with independence, women would gain access to education and take their place in social and economic development of the new democracies. It was on this premise that post-colonial Africa structured its education at all levels in order to meet both social and economic needs of the country that define development in the contemporary society (Woolman, 2001). In other words, provision of education to the citizens of a country (particularly women) would have a direct impact on the social and economic development of the country (Masanja, 2010). Consequently, countries with sound education systems, with clear mainstreaming policy would experience improved maternal health, low infant mortality rate, improved health

care and high economic growth (Lopez-Claros & Zahidi, 2005). Given the current gender disparities at all levels of education, many governments seem to have pursued the concept of economic development with limited regard for the place and role of women in this endeavour. As a result, Masanja (2010) observes that since colonial times, women have been discriminated and disregarded when it comes to access to education at all levels. This view is shared by Assié-Lumumba (2006) who admits that most policy statements by most governments were inherited from the colonial governments and remained impediments in the policy provision for equal access to education in Africa. For instance in 1970s, education policies in Kenya, Nigeria and Egypt focused more on education for manpower (not womenpower) development in order for the graduants to function effectively in the spheres of national development (Majanja, 2010; El Sanabary, 1997).

Thus the major challenge to gender parity in most African countries has been a result of lack of balanced attention between policy goals on gender parity and those of economic development. Gunawardena, et al. (2004) noted that "gender, higher education, and development have rarely been intersected leading to a silence in terms of policy, literature and research studies" (p. 2). This claim implies that such an intersection would have realized the pivotal role of women in economic development. Assié-Lumumba (2006) agrees with this view, noting that gender inequality in education at all levels was occasioned by weak policy frameworks in most African countries.

It has also been difficult for most African countries to focus on specifics of gender equality in education because of the changing trends in global economic policies. For instance in 1960's and 1970's, many global institutions like the World Bank, International Monetary Fund (IMF) and individual economists believed that higher education was more crucial in enhancing economic development compared to primary education (El Sanabary, 1997). As a result, many countries in Sub Saharan Africa developed their policies on this understanding, emphasising education for manpower development as informed by human capital theory. The 1990's witnessed a shift in policy by the IMF and the World Bank with regard to higher education. The shift was informed by the conviction that only primary and secondary education was essential in poverty eradication in Africa. The effect was that the global institutions influenced policies on higher education, reduced their funding for higher education from 18% to 7%, which resulted in low enrolment and erosion of quality in higher education (Bloom, Canning, , & Chan, , 2006). The recent changes in World Bank policy framework-particularly through its reports: *Knowledge for Development 1999* which established the role of Mathematics, Science and Engineering in economic development and the 2002 publication, *Constructing Knowledge Societies: New Challenges for Tertiary Education*, that underscored the place of "tertiary schooling in building technical and professional capacity" (Bloom, Canning,& Chan, 2006, p.9) resulted in policies that emphasised the role of higher education in economic development. The foregoing section briefly highlights how policy practices and lack of intersection have influenced the thinking about higher education. The influence by the global financial institutions has focused more on economic development across its policies, with limited attention to gender balance. This paper argues that most countries in Africa were preoccupied with the need for economic development as emphasised by the influential bodies at the expense of equal gender representation. The paper does not in any way suggest that no due regard was given to this important dimension of development, but the emphasis on economic development overshadowed all other aspects that can be addressed in the process of providing higher education including gender representation.

3. Conceptual framework

What triggers why people move and behave the way they do has been a concern of motivational psychologists for a long time. As such, both sociologists and psychologists have over the years put forward various explanations to unravel the mystics behind human behaviour. In this paper I present a conceptual framework that details the convergence of expectancy-value, attributive and self-efficacy theories of motivation and how they help to explain the decisions taken by women to study mathematics and eventually fall out of favour with careers in mathematics.

Theories of motivation explain the way people behave in different ways. They expose how people differ with regard to their levels of motivation and the alignment or nature of motivation that triggers and strengthens their behaviour (Bown & Ryan, 2004). The authors for instance acknowledge that some people may go to work because they find their jobs meaningful and enjoyable while others go to work because of their financial constraints. Likewise, they further observe that "some students study out of curiosity and an inner desire to learn while others only study to obtain good grades or meet the requirements" (p.105). These motivations are critical in attempting to understand what motivates women to study mathematics and later on leave the career.

This paper draws on expectancy-value, attribution and self-efficacy theories of motivation. An understanding of these theories will allow for the exploration of the pertinent aspects that motivate women to pursue mathematics in higher education and later, abandon it for careers in humanities and social sciences. Expectancy value theory has been used to explore and understand the motivation behind human conduct. In its widest sense, it states that "individual's expectancies for success and the value they have for succeeding are important determinants of their motivation to perform different achievement tasks" (Wigfield, 1994, p.50). This theory is anchored in the belief that people succeed when they engage in activities, behaviours or experiences that they believe they are proficient (Dörnyei, 2001 a) (p.57). Öztürk (2012) points out that achievement of success is based on the positive value associated with the things people engage in. In this belief, motivation theorists argue that there are different constructs that can provide an explanation about how motivation influences choices, persistence and levels of performance in a given task among people (Wigfield. A. & Eccles, 2000). This forms the basis of expectancy-value theory of motivation. The authors point out that expectancies and values influence achievement choices, which have a spiral influence on performance, effort and persistence. However, expectancy and values are themselves influenced by "task specific beliefs [including] ability beliefs, the perceived difficulty of different tasks, individual's goals and effective memories" (Wigfield & Eccles, 2000, p. 69). Anchored on such constructs and beliefs, Wigfield et al (2009) acknowledge that individuals and [countries] engage in instrumental activities that are basic for the achievement of valued outcomes. These particular beliefs are essential, first in helping to understand the values and expectations that keep women in mathematics on one hand, and on the other, to explain briefly why countries adopt and pursue gender equity policies in higher education. Thus in a way, a better way of encouraging women to stay in mathematics is not only to increase their levels of expectancy in mathematics classes and careers but also by intentionally organizing the conditions in which they are optimistic and highly motivated (Dörnyei, 2001a). However, expectancy-value theory is not sufficient in providing an understanding what attracts and sustains people in a particular discipline or field of study and eventually abandoning careers in that particular field. In this regard, I use attribution theory of motivation to help us in mapping out an individual's or institutions' previous circumstances (experiences) that are responsible for his or her current practice (Wigfield, Eccles, Roeser, & Schiefele, 2009).

People have tendencies of learning from past experiences and modelling the current choices, persistence and performance on these particular experiences. Motivation theorists explain such experiences through attribution theories of motivation. Attribution theory holds that attributing certain behaviour and consequences of an individual is instrumental in shaping his or her emotion and behaviour (Harvey & Martinko, 2009). For instance if, for some reason a student performed poorly in a mathematics test and realizes that this resulted from her failure to attend classes and revise for the exam, this is described as *internality attribution* for it stems from the students lack of commitment to the discipline. In a case where the poor performance is a result of poor instructional strategies and lack of motivation from the teacher, then the poor performance is externally instigated; in this case *externality attribution* provides the explanation for poor performance. Thus the motivation behind women who persist in mathematics can be explained in light of externality and internality attribution predispositions. For instance characteristics of a family, peers, teachers, institutions along with personal experiences in mathematics classes can influence the choices women make with regard to careers in mathematics. It is therefore important to explore the biographies and background of women in mathematics in order to establish how these factors influence the choices they make. However, even with these theoretical explanations, individuals should have the capacity to make choices and the persistence necessary to pursue them. This cannot be sufficiently be explained by theories of expectancy-value and attribution motivation. Self-efficacy theory becomes the point of intersection for these theories in explaining women's motivation to study and eventually leave the field mathematics.

Graham & Weiner (1996, p.2) define Self-efficacy as "individuals' confidence in their ability to organize and execute a given course of action to solve a problem or accomplish a task". In other words it refers to people's decisions about their capacity to consolidate and accomplish certain courses of action for the sake of attaining selected types of performances (Bandura 1986). Based on these definitions, motivation psychologists argue that people can only engage in an intended behaviour or task if they have full control over it. Thus self-efficacy is about individuals believing in themselves, having strong faith in their ability to perform the activity and the way others perceive this particular behaviour. Precisely, it is the individual's determination and belief in undertaking certain tasks. Thus increasing individual's self-belief to undertake certain tasks has a positive effect on how they will perform the activity (Bandura, 1977). Bandura observed that self-efficacy had an influence on the choices and activities people engage in, how they persist in a particular activity, the effort they expend and eventually what they achieve. Self-efficacy is acquired from information about personal observable experiences, performance of selected tasks, physiological reaction and observation of others through social contacts or

interactions (Schunk, 1995). Bandura (1986) and Schunk (1989) are of the view that it forecasts among other things outcomes of cognitive skill learning, career choices, assertiveness and coping with *feared* events. In my case, decisions made by women to study mathematics at the university and eventually abandon it for other unrelated careers could be explained by these factors (Schunk, 1995). Statistics elsewhere in this paper shows that though not well represented, the few women who take on mathematics may be assertive, capable of exuding confidence and therefore making good choices.

Thus the intersection of expectancy-value and attribution theories is founded on individual self-efficacy. Making choices is dependent on one's expectations and the value of the expected choice, but it is founded or anchored on people's capacity to pursue these choices.

4. Gender representation in science in higher education in Africa: a new trend

Although policy practices and declarations as reflected in the earlier section had negatively impacted on gender representation of women in higher education in Africa, the recent past has registered impressive progress in Sub-Saharan Africa. Most African countries have taken bold steps to increase representation in education, politics and other sectors of the economy, thus dispelling the myth that gender representation cannot be realized in Africa. In education, some countries have attained almost equal representation in education with regard to gender at lower levels of education and even at tertiary levels (Majanja, 2010). In South Africa for instance, the constitution of 1996 and the 1997 White paper No.3 outlined the place of state institutions in enhancing transformation and development of the entire society (Badat, 2010). Through the constitution, state institutions-including state universities – are expected to nurture and facilitate achievement of equality and human rights as enshrined in the Bill of Rights while the Higher Education Act provided for institutions to tailor their programmes in a way that they respond to South Africa's human resource deficit, economic and development needs as well as equal access to to education (Badat, 2010). In one of its goals, the Department of Education (DoE) in South Africa "stressed the need for higher education to enhance access for blacks, *women*, disabled and mature students…equity access and fair chances of success for all…while eradicating all forms of discrimination and advancing redress for past inequalities" (Department of Education, 1997, p. 1, 1:13, 1:14). With these policies in place, South Africa has more women than men in its higher institutions of learning. Overall, the (Council on Higher Education(CHE) , 2009) reveals that by the year 2007, the number of women in higher education in South Africa had outstripped that of men (women-55.5% and men-44.5%). Although gender representation at postgraduate in South Africa is still tilted in favour of men, statistics show a signifcant improvement between 1994 and 2007. Women access at doctoral level in 1994 was 29.7%, 41.2% in 2000 and 41.6% in 2007 respectively (Badat, 2010).

Similar efforts have been made in other countries in Africa with regard to gender representation in higher education. For instance in Rwanda, the number of women who enrolled in higher education increased from 2,511 in 2001 to 3,621 in 2005 (Huggins & Randell, 2007). The authors acknowledge that although there is an increase in the number of women who enrol in higher institutions, they are still under represented. For instance in 2003/2004, of all the candidates who sat for A-level exams, 74.5% passed the exam. Out of this, 48.31% were women of which, only 8.18% gained admission to government higher institutions. In its private institutitons, Rwanda has more women, 52.7% compared to 46.3% men enrolled (Masanja,2010). Similar trends of improvement have been recorded in Tanzania. In a bid to increase access for women, Tanzania governent introduced pre-entry academic programmes that significantly increased the number of women enrolment in higher education by 7.5% in 2003 to 23% in 2006 (Montanini, 2013). The author notes that similar programmes were introduced in Ghana, Kenya and Uganda to help increase women access to higher education. Generally, as Masanja (2010) puts it, most countries in Sub Saharan Africa have in the recent past, allocated large percentages of their budgets on education, it is hoped that more and more women will have access to higher education.

While Sub-Saharan Africa has started recording noticeable improvement in gender representation in higher education, representation at this level, like many other parts of the world remains skewed in favour of men. The skewness is particularly noticeable in various disciplines in univeristy faculties. In fact, the slanted gender representation in various discipline helps to be more critical of the third Millenium Development Goal (MDG) that commits itself to promotion of gender and empowering women (Assembly, 2001) without clearly defining the dimensions these efforts take in different disciplines at the university. To this extent (Colclough, 2007) acknowledges that the "MDGs makes no mention of equality but only to achieve enrolment parity…" (p. 57) at various levels of education by the year 2015. In this case, it is possible to make some progress with regard to gender parity without taking some of the qualitative aspects implicit in the very concept of equality such as the

concurrent gender representation in all the fields of knowledge in higher education and more critical, finer details that may be unique to women that impact on their urge to enrol in these fields.

Generally, studies on inequality in higher education have been framed along gender, racial, rural-urban disparities, core-periphery distinction, and first - third world countries (Higgs, Higgs & Wolhuter, 2004). In these dimensions as noted above, most African countries have made some progress. It is however important to provide some insights into the progress made in pursuit of gender equality in the field of Science, Technology, Engineering and Mathematics (STEM). This is particularly important in the sense that most studies record gender imbalance that provide a general improvement with limited regard to specifics of disciplinary improvement. For instance studies show that of all the students who enrol in higher education in Africa, less than 30% enrol in the fields of agriculture, science, technology, health sciences and engineering (Masanja, 2010 (Yizengaw, 2008). In Nigeria, a survey by Aderemi,et.al (as cited by Masanja, 2010) that involved 1,345 graduate women revealed that the number of women in science, mathematics and technology had increased by 70% with a significant percentage of the increase being between 1990 and 2000. In South Africa, although the number of women in science is still very low, notable improvements have been recorded in medical schools. For instance between 1999 and 2005, enrolment in this field increased from 49.7 % to 56.1% (Wildschut, 2008). Available data in Kenya indicate that women in engineering represented 8% while in physics at bachelors and PhD levels, women represented 15% and 11% respectively in 2008 (Republic of Kenya, 2010). Overall, statistics from the Ministry of Education, Science and Technology (MOEST) revealed that in 2006 women represented less than 25% of Kenyan students enrolled in the fields of natural or computer sciences, medical sciences, mathematics, and engineering (Wasike, 2013, p. 149). There was however some improvement for the statistics released in 2007 which put women enrolment at 29% in mathematics and computer science but engineering remained low, at 6%. Although the foregoing literature presents a marginal representation of women in the fields of Science, Mathematics, Engineering and Technology in Sub-Saharan Africa (Adams & Kruppenbach, , 1986), it does reveal that there are some women in these fields in higher education. It also signals some gleam of hope given the growing number of women in science in general, and the interest in the subject of gender representation in STEM by researchers. What remains unexplored is why some of the few women who excel in STEM choose to leave these fields, even with full knowledge that the fields are desperately lacking in terms of gender representation. In fact, the picture presented is that governments are addressing gender disparities, unconscious of the few but significant numbers that are leaving science and mathematics for other careers in humanities and social sciences.

5. Gender representation mathematics

Gender representation in education and Science, Technology, Engineering and Mathematics. (STEM) in particular has dominated literature in Sub-Saharan Africa and the rest of the world (Republic of Kenya, 2010; Masanja, 2010; Wasike, 2013; Yizengaw, 2008). In fact, most of the existing studies present the reasons for gender imbalance in this region and provide detailed statistics that paint a desperate picture of the state of women in STEM. Statistics, however low they may be, still point out that there are some women in these fields, who despite the challenges and stereotypes prevalent in these areas navigate the storm to successfully complete their courses. There is however inadequate knowledge about women who have chosen to move into other areas, particularly humanities after completing their undergraduate or masters programmes in mathematics. This paper, having presented a brief description about affirmative action in higher education and science general, focuses on women who study mathematics but end up in fields of humanities and social sciences that hardly call for knowledge in mathematics. This section focuses on the gender representation in mathematics in Sub Saharan Africa, after which, it will shed light on reasons to why people make change careers.

Mathematics has been described as the foundation of modern science and technology and the most precise, convincing and clearest way of passing across infromation (Cockcroft, 1982). It is a knowledge area that positions a country for both local and international competitiveness, particularly when conceptulized in the context of modern science and technology. In fact (Atkinson & Mayo,, 2010) note that social and economic development of most developed countries has been based on science-particularly with regard to creating well paying jobs that lead to improved living standards and industrial growth. Unfortunately, while other continents have made better use of mathematics, encouraged women particapation, “Africa still lags behind when it comes to providing access to mathematics education to women” (Asimeng-Boahene, 2006).

Under representation of women in mathematics has generally been explained variously by different schools of thoughts. First, unequal representation has been explained on the basis of genetic composition between men and

women with regard to the way their brains are developed, structured and positioned. In reinforcing this claim, it is argued that women are "intrinsically disadvantaged in studying science and mathematics" (ibid, p. 712) and this explains their under–representation in this discipline. The argument is that some aspects of their brains are not fully developed due to some discrepancies in their genes. Second, the more dynamic and popular explanation has it that women have as equal capacity as men to excel in mathematics (Asimeng-Boahene, 2006). The author argues that with this understanding, scientist are made as opposed to the former view that they are born. Girls/women are however overwhelmed by discriminative social structures and commentary that discourage them from participating in mathematics. All these views constitute the genesis of imbalance in women representation in mathematics.

As stated, reasons behind under-represeantion of girls/women in mathematics are many and varied: some emanate from one's personal disposition while others are external and beyond their control, yet others have historically and socially been constructed. At personal level, Githua & Mwangi (2003) in a study among secondary school mathematics teachers in Kenya seeking to establish why girls performed dismally in mathematics found that girls were not well motivated and exuded fear and panic in relation to learning mathematics. This resulted from lack enthusiasm and self confidence among them. The authors also established that girls were not intrinsically motivated during mathematics lessons. Other studies have indicated that girls' attitudes play a significant role in enlarging the gender gap in mathematics. Their lack of confidence, anxiety about mathematics and the feeling that mathematics is a male's world contributes heavily to their under representation in this field (Wasike, 2013). Asimeng-Boahene (2006) argues that society in general is responsible for enhancing gender disparities in mathematics in Africa. The author notes that first, boys are socialized to solve their problems individually, to be physical and independent while girls are expected to be submissive, affectionate and dependent on other people [men]. Besides, families allocate more domestic tasks to girls which take most of what would have been their valued time to study. Thirdly is the existence of what has become a strong stereotype that mathematics and sciences can only be done by males. This stereotyping is dipicted in among other things the people girls encounter as mathematicians and scientists in general. In addition to this, studies have identified classroom experiences as having an effect on the extent to which girls will be motivated to engage in mathematics (Wasike, 2013). For instance during teaching and learning sessions, examples used, illustrations in textbooks and the language seem to disadvantage girls (Githua & Mwangi, 2003). Other studies also point at "teachers' subject knowledge and teaching style [as] vital factors", along with their "enthusiasm that captures pupils' interest and motivates them to study a subject" (Hutchinson, Stagg, & Bentley, 2009).

In higher education, enrolment and success of women in mathematics is dependent on the extent to which they react to and overcome the barriers inherent in the context of mathematics as a discipline and those involved in the teaching mathematics. At postgraduate level, Lacampagne, et al (2007) identified several barriers that undermine women's participation in mathematics. First, the authors acknowledge that although encouragement and moral support from the family play a crucial role in motivating female graduate students (and males) to study mathematics, men do not regard the encouragement as much as women when it comes to making decisions to enrol for mathematics. Secondly, they isolate ineffective styles of communication and competition as key barriers to women's participation in mathematics. Communication approaches in mathematics were described as "impressive and mystifying" rather than "explaining and enlightening" to facilitate teaching and learning of mathematics at postgraduate level. Thirdly, "unfamiliar epistemology of graduate mathematics" (p. 244) characterized by abstraction and content that is far removed from reality motivates most women to stay away from mathematics. Finally, its embedment in men's culture and conflict with family duties and responsibilities diminishes women's rigour to pursue a field that is popularly known to be a domain of men. Surprisingly, most women at this level have traversed a rough terrain at primary level, overcoming the prejudices and stereotypes to the pinnacle of mathematics, yet the challenges are even more insurmountable at this level.

With challenges and obstacles at all levels, women's participation on equal rating with men in mathematics, it seems, is a distance away from being realized. This is particularly when studies show that in Sub-Saharan Africa; women are underrepresented and perform poorly in mathematics compared to men (Wainaina, 2011). For instance in South Africa, the number of women graduating at PhD level in the broad fields of science has been fluctuating. A report by the Academy of Social Science of South Africa (ASSAf, 2010) revealed that the number of women graduating with PhDs in natural and agricultural sciences, engineering, science, material & technologies had dropped from 41% to 36% and 17% to 15% in 2000 and 2007 respectively. In another study that focused on enrolment in mathematics in fifteen universities in South Africa, there was a general declining trend between 1990 and 2000, only for a positive change to be realized between 2000 and 2007 (Engelbrecht & Harding, , 2009). The study however did not provide details on gender representation in mathematics in relation

to this improvement. In Kenya, The Master Plan on Education and Training in Kenya 1997-2010 revealed that women were underrepresented in mathematics along with other science based courses (Wainaina, 2011). The situation in West Africa is not different. Alutu & Eraikhuemen (2004) reported that empirical studies in selected higher institutions in Enugu state, Nigeria between 1990 and 1996 discovered low enrolment of women in mathematics, science and other technologically oriented courses. In another study conducted by Ebo and Isong (2000 as cited by Alutu & Eraikhuemen, 2004) to determine women participation in mathematics and science in higher education at the University of Calabar and University of Uyo, it was found that women were under represented in fields that utilized mathematics. Although this trend is worrying given the' commitment by most African governments to enhance gender equality at all levels of education, it seems some of the few women who excel in mathematics look for better career opportunities out in humanities and social sciences.

6. What motivates women to study mathmatics and science?

Although women participation in mathematics has been riddled with both personal, cultural and social factors at all levels of education, the drive to intensify their particpation need not to be interrupted. Already, many countries have put in place policies, practices and allocated resources to enhance equal gender representation in mathematics. This is particularly important not only because of the role of mathematics in economic development but also the value of an equal and just society that acknowledges and appreciates the abilities of women. Accordingly then, there is need to direct resources, energies and time in research to establish what motivates women to quit this field in a country that is finally motivated to encourage equal representation in mathematics. However, it is imperative to examine briefly, factors that determine/ influence women's career choices, particularly careers in mathematics.

Schreiber (1998) observes that career choices made by women should be conceptualized in the context of the prevailing social and cultural beliefs that influence how people perceive their abilities and roles in the society. This is particularly the case when a career is defined as "a set of work related activities in which a person is engaged through his or her life time" (Karsten, 2006)p.218). As such, studies in Brazil, Turkey and Mauritius have shown that cultural factors determine whether girls will pursue careers in information technology (Trauth, Quesenberry, & Huang, , 2008). In Brazil, the study revealed that although women constituted 51% of the population, they were under represented in Information Technology (IT). This was largely because parents have greater influence on girls career choices in Brazil. Contrastingly, studies in Mauritius indicate that social cultural factors, including families and national cultures that underlined the value of information technology have positively influenced the increasing numbers of women in IT career. Similarly, the presense of women in computer programming, encouragement of girls by their families to take careers in IT, emphasis of gender equality and the fact that national education policy is supported by the government (ibid) have resulted in an increase in the number of women in IT in Turkey. Family obligations have also been cited as having a bearing on women's career choices. Such obligation include geographical immobility resulting from commitment to the spouse, "responsibility for the maintainance of the relationship and the difficulties of coping with household labour" (Shakeshaft et. al, 2007, p. 114). Given that IT is one of the fields in science and technology that rely on mathematics, it is important to find out some of these factors that underpin women's selection of mathematics as a career in higher education and those that motivate them to change careers from mathematics to careers in fields in humanities and social sciences.

7. Women and career changes

Although women have to make difficult career choices, more often influenced by personal and social-cultural factors, some of the choices they make are untenable and therefore they contemplate changing their careers. This happens more often because studies show that presently, they are well positioned to benefit from serendipity-("seredipity occurs when opportunity and preparation converge" p.219) in the contemporary society where their careers are nolonger unplanned and non-linear (Karsten, 2006). Consequently, (Burke, 2000) in a study, *Motivations to Teach: Post-Baccalaureate Students* in the United States of America (USA) among people from different careers who wanted to change their careers to teaching (USA) established that their wish to change were informed by: a) the desire to make a difference in other peoples' lives and the world in general, b) wanting to work with children, and c) dissatisfaction with their current positions. The reasons advanced here for the changes in careers reflect on individual/personal choices in relation to what they expect from any job. While this study was conducted in USA- a developed economy- there is need to conduct a study among women who formerly were in careers in mathematics and they changed their careers within the context of Sub-Saharan

Africa, which hosts a wealth of developing economies. It is however important to reflect on the nature of mathematics as a starting point of understanding what inspires women to enter into careers in mathematics and to leave these careers for humanities and social science careers.

8. The nature of mathematics

Studies in the field of mathematics have articulated different conceptions about the nature of mathematics. Dossey (1992) observes that conceptions attributed to mathematics tend to determine the way a particular society perceives it. Such conceptions, Dossey acknowledges, impact on how mathematics is taught, disclose the nature of mathematics to children and determine their conceptions of mathematics and its place and function in the society. Generally, Young-Loveridge, et al (2006) observe that there are those who view it as "a fixed body of knowledge that is presented to students, and internal conceptions that view mathematics as personally constructed, internal knowledge" yet others have "contrasted mathematical content (knowledge and procedures) with mathematical processes (reasoning, problem solving, communicating, and making connections)" (p. 583) in trying to explain the nature of mathematics. From this understandings, Belenky (1997) in a study established that women at different levels of education 'know' mathematic through silence, received knowledge, subjective knowledge and constructed knowledge. These perceptions are typical of attribution, expectancy-value and the self-efficacy theories of motivation. Although this generalization was criticized as having failed to consider men in the study, it was reinforced by essentialist beliefs that "there are characteristics which all women share [which by extension] describe all women's knowing" (Lacampagne, et al, 2007, p. 247). These assertions, though derived from well documented empirical studies are limited to the concept of 'knowing' with regard to mathematics. This may not however provide an explanation as to why some women remain loyal to careers in mathematics while others choose to leave. Although the nature of mathematics may afford women a common approach, there is need to isolate the motives behind behaviours after graduating with a first degree in mathematics.

Drawing on Bernstein code theory, the nature of mathematics as a classified code bestows women in mathematics some form of power that determines their social and economic stations in the society. This is particularly the case where "a subject is taught in isolation from each other, [that is] mathematics is clearly distinct to other subjects areas, there is a strong boundary between each subject, and so, [its] classification can be described as strong" (Cause, 2010)p. 5). This perspective takes into cognisance Bernstein's (2000) view that classification "is the means by which power relations are transformed into specialized discourse" (p.xvii). Discourse in this sense refers to among other things the way people think, articulate issues with regard to knowledge in their fields and what influences how they think. Whereas the nature of mathematics accords women a measure of power, knowledge on how the discourse of mathematics conditions them into thinking and behaving in particular ways and what eventually triggers them to abandon this way of thinking remains scarce. This perception is born out Bernstein's assertion that where strong classifications exist, contents are well insulated from each other by strong boundaries (Bernstein, 1971, p. 49). The logic here is that the choices people make, their expectations and the value they attach to them may change over time. In other words, exposure to mathematics for a long time - in school, during training and at work- may motivate people to think in particular ways, which may be restrictive, thus prompting one to consider alternative careers. It is not however clear whether this perception about the nature of mathematics can result to career change. What is clear is that beyond maintaining boundaries between subject contents, classification can also refer "to other aspects such as playground areas, assessment strategies, relationships or even the layout of classrooms" (Cause, 2010)p. 5). On these grounds it can also help to explain career boundaries and the power struggle immanent among career women in mathematics as espoused by self-efficacy theory.

9. Methodology

Conceived as an exploratory study of what motivates women to study mathematics and eventually abandon careers in mathematics, three women were selected and interviewed in order to provide an understanding of what motivates and sustains their interest in mathematics to the time they part ways with careers in this field. These women (most of them teachers) had studied mathematics during their undergraduate in different universities in Sub-Saharan Africa and were proceeding with their post-graduate studies in the departments of Education and Curriculum Studies in the faculty of education at the University of Johannesburg. This sample was appropriate in the sense that it had experienced mathematics at undergraduate level. The participants had also enrolled for postgraduate programmes in education yet they had strong backgrounds in mathematics.

Data was collected by use of interviews. Interviews were particularly suitable tools through which participants' lived experiences could be established by exploring environments and meanings of unique experiences (Charmaz, 2006). Given the wide spectrum between structured and unstructured interviews, semi-structured interviews were used for data collection. The appropriateness of semi-structured interview stems from the understanding that the nature of the study and the type of participants do not allow for multiple methods of collecting empirical data. Besides, semi-structured interviews are organized around themes, allowing the investigator a chance to probe and gain more insight into the issues under investigation (Gray, 2004). The interviews focused on what motivates women to study mathematics at undergraduate, the nature of mathematics and the motive behind their decisions to change careers from mathematics to other fields in social science. The data collected was transcribed, categorized into more meaningful units for interpretation, prior to identifying the emerging themes.

The next section presents the finding of the study. The first section focuses on the analysis of the responses of why women choose to enroll in mathematics at undergraduate; it is followed by what is thought as the nature of mathematics and finally, the motives behind women's departure from careers in mathematics.

10. Discussion of findings

10.1 Enrolling in mathematics: the reasons

Given that human beings differ in the way in which they are motivated, the rationale and motives behind women's enrolment in mathematics in Sub-Saharan Africa are surprisingly different. This study shows a long trajectory of women battling, at times with a lot of delight, interest and love for mathematics right from primary school, to enrolment that is a result of a powerful fight back that characterize the stereotypes advanced by male students in mathematics at the point of enrolment, classroom environment all the way to the to the graduation day and professional life.

Women like men have a burning passion to study mathematics. In an interview with one of the women, she noted; "I was good in mathematics. You know, I was extremely good in mathematics." Being good implied that compared to all other subjects all the way from primary school, she performed best in mathematics. It is not just being interested in mathematics, this participant also underscored the fact that compared to English and literature, mathematics does not require as much time to study as these other subjects: "It doesn't require too much work….I didn't want to do literature as a subject you see, because it would involve a lot of reading a lot of books unlike mathematics where it involved knowing the formula and how to apply it full stop". On this understanding, the perceived outcomes from classroom experiences despite the difficulties and beliefs associated with mathematics form the basis for enrolment in mathematics (Wigfield & Eccles, 2000, p. 69). One of the women pursued mathematics because throughout her schooling time, most girls and women preferred keeping away from mathematics. In her pursuit, she says, "Ah… it was because ah… I saw, most women, they were running away from mathematics…" Surprisingly, her enrollment was a protest against men who are so bend on discouraging women to pursue mathematics. This feeling is articulated in her narrative:

> "When I was applying [enrolling] for mathematics, a certain man said 'no, don't apply for mathematics. You need to go to languages because you qualify there… in languages so you can go'. Then I said 'why these people they say that I should go for languages and not mathematics' and when I was asking my friends… my colleagues… they were saying 'no mathematics is difficult so you cannot study mathematics'. Then I said I need to go to mathematics and see what they are talking about…that mathematics is difficult. I need to see the difficultness of mathematics. That is why I applied for mathematics…at my undergraduate. Because many people they were saying mathematics is a difficult, mathematics…yah you can't study mathematics, ehhh, you will be weeded*(01:24). So I said 'ok, let me go and see'.

The motive expressed herein is the urge to challenge men that mathematics is not a private domain for them. On this basis, this participant felt that by enrollig in mathematics, she would help to challenge the myth that mathematics is difficult and her own enrolment was a highly valued engagement worth of her course (Wigfield et al, 2009; Harvey & Martinko, 2009). However, what come out clearly is that negative comments made to discourage women from enrolling in mathematics became the source of motivation for this participant.

Decisions on whether to specialize in mathematics are also influenced by the state, close family members and friends, and teachers. Out of the interview with these women, one of the respondents indicated that the state encouraged girls to study mathematics: "yes of course I was hearing [from the ministry of education] that women you need to study mathematics, sciences…in my country [Malawi]… these sciences, you need to go for Biology or Physical Sciences. It was encouraging".

Relatives who have studied mathematics and were working in the mathematics related fields also serve as a source of motivation: "Yes we have relatives who are may be engineers and all that… so I assume we are slightly mathematicians and all that". A participant from Botswana remarked. Similarly, another respondent from Malawi acknowledged that a few of her relatives and friends encouraged her to take mathematics at undergraduate. At a time she had almost given up, she says that "my friend said, 'no, let us continue' ''. Some other forms of encouragements from very close relatives came in form of threats. When this participant felt overwhelmed and wanted to cross from mathematics to Physical Education (PE), her husband, who had always been very supportive retorted, "After getting that degree in PE, don't come with that degree here at home…. eee, nowhere to go with that degree. 'Not here, not in my house. I don't want that degree here'". Clearly, participation in mathematics was largely attributed to encouragement (whether positive, negative or even threatening) from the state, close relatives and friends (Harvey & Martinko, 2009).

Teachers also play a central role in determining who pursues mathematics and who does not. Interviews with these women presented a world of differences among teachers that, though divergent, motivated them to work hard in mathematics at secondary level, all the way to the university at undergraduate level. While some teachers used all the available motivational strategies to encourage students to pursue mathematics to higher levels, others were least engaged with such strategies-focusing on demoralizing language to scare aware female students. For instance one of the participants (from Botswana) had this to say of her mathematics teacher at high school:

> Maybe actually the reason why I ended up going into mathematics is because we had this innovative mathematics teacher in secondary school. She would bring with her this Super Cane cooks (content quotation (20:13), we would compete for the Super Cane, one who scores higher is going to get a Super Cane. So I think maybe this is where this mathematics thing came from… because of this mathematics thing, the teacher was so dynamic, so innovative and you know prizes and all that so it was fun, although I was still good in mathematics and I knew it wasn't taxing in terms of time and effort.

This view is supported by Hutchinson, Stagg & Bentley (2009) assertion that that pedagogical skills used by teachers are vital ingredients that motivate women to study mathematics along with their passion that seizes student's interest and inspires them to study a subject.

Contrastingly, not every teacher gets to motivate students in the same manner. One participant from Malawi contends that it was the spiral negative rebukes from her mathematics male teacher that sustained her quest to pursue mathematics. For girls who could not provide correct answers to his questions, the participant had this to say about one particular teacher:

> When I was in form three, our mathematics teacher…ah…ah…when you try to answer a question and you fail, as a lady, he was saying, 'go and get married' he was discouraging us. This man, aai…, 'go and get married, go and get married', but if it is a boy, he was quiet. And that thing it was… to me… it was aai…it was bad, yah, he was saying, 'go and get married to Ngweda'. Then I was saying, why not tell the boys to marry? 'Ah mathematics with girls, they don't go together. Go and get married'. That man, ahh…no.

Generally, women's participation in mathematics is largely influenced by the approaches taken by their teachers in high school. For this participant, self-determination and need to overcome the inherent stereotypes against women in mathematics (Wasike, 2013) coupled with the belief and determination that she can do well (Bandura, 1977) in mathematics were crucial motivators to enroll for mathematics.

10.2 Obstacles after enrolment

It also emerged that the content and nature of mathematics, its scope and the methods of teaching mathematics at the university constitute another challenge among women. One participant indicated that some topics in mathematics became more and more difficult as you advanced to higher levels of mathematics; "The formulas were easy but as you move up the ladder it becomes difficult when you do Algebra, trigonometry and all that". Another participant noted that "calculus according to me was a bit challenging". The nature of mathematics also

relates to the scope of the content and thought pattern involved in studying it (Belenky ,1997). Mathematics also requires people who naturally think very fast or have rigorously trained to think fast.

> Mathematics is a good subject, is for, is for, you know the way I…I….I perceive mathematics, my perception of mathematics-is… is…is the high level thinking order…. It requires somebody who is got very high level of thinking skills who can think fast.

It is possible that most people are not trained to think fast as they engage with mathematics at all levels. Fast thinking provides one with the speed to deal with long exams that constitute both short, simple calculations and long and complex mathematical equations. This well captured by one of the respondents: Mathematics requires

> [People] who can think fast because when you write a mathematics test for example an examination is two hours, is a very strong paper… is long. So is either you get it or you don't'… Because if you don't get it, you can spend one hour just trying to solve one question, you see what I mean".

These perceptions are typical of Young-Loveridge, et al (2006) view that mathematics to some people is personally constructed, internal knowledge that involves content (knowledge and procedures) and mathematical processes (reasoning, problem solving, communicating, and making connections).

The other challenge relates to the way mathematics is taught at various levels of schooling. As one advances to higher levels of education, new and subtle teaching approaches are adopted. Although one of the respondents insisted that; "mathematics at the university is mostly calculations, it's not essays. It is calculations, same thing", another one rebutted noting that:

> Ahhh… teachers at the university level most of the time these teachers were just telling us about the topic, just introducing us to the topic and they were giving us assignments to go and solve on our own, whatsoever, yah. They were just introducing to us a topic after introducing, of course they were teaching but not so very. They were saying you were very old; this is a university you need to look for information on your own… whatsoever. So ah… of course it was tough, mmm".

These variations in the pedagogics of mathematics from the participants at university level point to some of the experiences women encounter in mathematics classes as they interact with the content and their teachers. Generally, it is a closed area of knowledge that bestows power to the participants as determined by the society (Cause, 2010). Thus those involved in teaching tend to have little to talk about but expect students to work independently given the power bestowed in mathematics (Bernstein, 2000). However, this mode of teaching is typical of instruction at higher institutions of learning.

10.3 Walking out of calculations: why

Women are motivated by different things as they decide to abandon mathematics for careers in humanities and social sciences. Personal experiences, close relatives and encounters with mathematics and the way it is taught seem to be instrumental in motivating women to leave mathematics. People seem to reach points of saturation that inform their changes in careers. An interview with one of the participant revealed this. On the nature of mathematics, the participant, having been involved in calculations all her life, felt that even if she advanced in mathematics, it would be all but calculations; "I was just done with calculations and all that eh…eh….[thus] at postgraduate there is nothing new to learn". As portrayed here, some women tend to assume that at postgraduate, the programmes and experiences are quite similar to those at undergraduate level, focusing on calculations, yet it the "belief is that and I also believe that whatever you need to know in mathematics you learnt it at undergraduate level to be honest" reinforces one's bid to change careers. This further implies that while the participant had excelled in mathematics, her expectations and the value of mathematics had reached a point where they hardly made any sense to her (Wigfield, 1994). As such, no more positive value is attributed to mathematics (Öztürk, 2012) hence the need to pursue it diminishes.

Although these views seem to influence the decision to reinforce the desire to leave mathematics for other professions, some other women feel that mathematics is not only about calculations but an avenue to enhance and sharpen one's way of thinking. A participant from Malawi was categorical about this: "mathematics, it gives room for me to think, the formulas, even the subject matter, when I am solving problems. It gives me room to think. How can I do this? How can I do that? How can I, yah". This also well captured by one lady from Zimbabwe; "it makes one to have a wider perspective rather than narrowing oneself".

Mathematics is one of the subjects that is most regarded in education systems across the world. Those who excel in mathematics are expected to secure good and well-paying jobs. However, even with such beliefs, it seems that this is not the case. It emerged that while mathematics is more involving and highly valued in the society; its economic returns are not always as hyped by the society. This perception is reflected in this narration by one of the participants from Botswana:

> I think one other reason…maybe the main reason if you could call it… that is I had seen how other students who were considered extremely intelligent students in their senior secondary years turned out really with their mathematics careers and I just did not like what I saw. I mean… I am talking about really good students, gifted students, all round students who were extremely good in everything, the ones who got distinctions in both Form 3 and Form 5 (Grade 10 and 12), ended up just being teachers and it broke my heart to see that. I felt like…that was a wasted talent. And I could see students who were just average students being CEO's and Directors of important companies and I asked myself: Is this right? How could this have happened to such good students? I came to the conclusion that it was this "Mathematics career thing". They were stuck in the teaching profession with no prospects of moving anywhere.

This reaction spells out the expectations women in mathematics have and what eventually happens. Mathematics itself, according to Bernstein (1971) is highly insulated and valued by the society. In academics, the society acknowledges those who study mathematics to have gained power of some kind, which influence the way they think, act and behave. To some women however, it fails to match to these standards and this paves way for them to move to other lucrative careers. In a way, they see themselves not making much progress on the basis of what they see those who graduated a head of them go through (external attribution) (Harvey & Martinko, 2009).

In an interview with another female student who is pursuing her masters in mathematics education, her decision to move out of pure mathematics stemmed from the feeling that her initial perception that the returns in mathematics would be good was a misconception: “mathematics has the higher social status but…but the returns are similar to those in social sciences….I don’t see any special regard for it in my country. In fact, economic returns in social sciences are better”. Like the participant from Botswana, this participant from Zimbabwe felt that the expected economic value from mathematics had evaporated (Wigfield, 1994; Dörnyei, 2001 a) and therefore could not see the need to carry on with mathematics (Harvey & Martinko, 2009). In a way, as Bandura (1986) puts it, this reduced their confidence and ability to organize and accomplish what they had envisioned as mathematicians at both high school and at the university.

Surprisingly, those who remain in mathematics within the teaching profession continue producing great mathematicians, yet their role is not financially appreciated by the state.

> Others of course ended up joining the academic community but even there you could tell that there were just restricted-not enough room to maneuver even in producing academic papers. I mean…they… they were good teachers and all that-and made an important contribution in terms of producing the next bunch of mathematicians, and basically that was just that-nothing else. And so I did not want to end up like that.

Women are not just intrinsically motivated to leave pure mathematics to other fields; their decisions are also attributed to close family members, in most cases males, who feel that they may not excel in mathematics. An interview with the participant from Malawi revealed this, among other factors that saw her reluctantly abandon her dream career in statistics at postgraduate level.

> The first reason is because of my relatives. I can say my brother was the one who told me to study mathematics education….. My brother told me that ‘oh if you go for statistics’ I wanted to go for statistics, I said calculus is difficult, I need statistics, then my brother said, ‘no, don’t go for statistics, you are here to pass, it is difficult.’ Ah…then I said, let me just go for mathematics education.

Relatives can also use other peoples’ experiences in mathematics to discourage women from pursuing their dreams in mathematics.

> Yah, he said, ‘statistics, your head will burst’, but I told him that when I was getting my first degree, I was doing very well in statistics, so I believe that maybe when I will be getting masters I will I can do well in Statistics(11:35). He said, ‘stop talking about that, some people…that some people stay maybe

> for 12 years before getting PhD in statistics. It is very tough, leave it and go for mathematics education'. Then what can I do?

As Harvey & Martinko (2009) put it some behavioral practices of individuals and their consequences are instrumental in influencing other peoples' lives. The feelings expressed above attest to the fact that career shifts among women are largely influenced by men. In some cases, the influence comes in form of threats.

Women are also motivated to move to other field because they are not generally encouraged to continue with mathematics to higher level. Both in their encounters with friends, relatives and group discussions reveal that the better option is to drop mathematics. Such overwhelming discouragement is reflected in these remarks from a female student doing her masters in mathematics education at the University of Johannesburg.

> And also another reason most of the times, I would talk about my experience as a mathematician, I don't see people encouraging me, my friends, teachers….everybody is not encouraging me including my relatives. When you say I will study mathematics, 'you are a lady, you can't. Mathematics is tough'. We are not encouraged (researcher's name). We are not. Everybody is discouraging us.

The point here is that self-drive and belief are the engines that could have sustained women in mathematics. But as expressed here, women by nature need constant encouragement in their endeavors as part of the lubricant to their success (Lacampagne, et al, 2007;Wasike, 2013).

Some women have a strong desire to work closely with people and observe changes in people as they interact with them. They tend to believe that mathematics limits them to some specifics that deny them what they feel they can achieve if they move out of mathematics. Through other fields like management, this participant believes, she can have a greater impact on mankind:

> I decided to pursue management and I like it and I think I realized that I like working with people because when you are in management, you really work with people, you coordinate, you…you bring people together, you solve problems and all that. I also realized I was good at that.

As Burke (2000) found out in her study, people aspire make significant changes in other people's lives and this aspiration triggers their desire to move from one career to the other. Making significant changes in other people's lives and the world in general is a relative term that should be understood at personal level. All the participants in this study were trained high school teachers. While teaching in itself involves transforming lives through educational experiences, it may be a different experience changing peoples' lives in a different career or profession.

11. Conclusion

This paper aimed at exploring the reasons behind women abandoning mathematics for social sciences and humanities in Sub Saharan Africa. In order to explore this phenomenon, an overview of the genesis of gender disparity in higher education in Africa was mandatory. To understand the dynamics involved in career changes among women in mathematics, expectancy-value, attribution and self-efficacy theories of motivation were used. The intersection of the two theories in self-efficacy-the personal drive, energy and self-belief carry make women more assertive in making difficult decisions regarding changes in careers. In understanding this phenomenon within the context of Sub-Saharan Africa, it was also necessary to review literature on Science, Technology, Engineering and Mathematics (STEM) given that some studies focused on all these discipline. The literature revealed serious under representation of women in all these fields in Africa.

Under representation of women in mathematics has been triggered by historical, social and political factors on the one hand and personal and genetic factors on the other. Policy practices, lack of adequate encouragement and stereotypes against women have been cited as crucial factors that contribute to under representation.

In conclusion, the study found that the move by women to change careers from mathematics was mainly informed by their decisions to enroll in mathematics. First, some women enrolled for mathematics at undergraduate because they had perpetually performed well right from primary school all the way to high school. This was in addition to the fact that mathematics required lesser time to study compared to other subjects. Second, mathematics has been highly regarded in the society and its place in technological development cannot be underestimated. This particular factor was pertinent among the participants in selecting mathematics as a

subject of study at the university. Then there are those who enroll for mathematics as a reaction to the myth that women cannot excel in mathematics. The other reason for enrollment in mathematics was its perceived status in education and the economic value attributed to careers in mathematics. While the view is true, the participants seem not to been clearly advised on areas in mathematics that would economically position them well in the society.

On the basis of these findings, several reasons were advanced for the migration from mathematics to other careers in social sciences. In the first place, some women got to appoint where they felt they had had enough of mathematics and therefore they needed a complete change. This was reflected in one of the respondent's remark: "I was just done with calculations and all that". The participants were also disillusion by the state of lives and the kind of jobs that were taken by those who had excelled in mathematics. On the contrary, those they had seen perform poorly in mathematics and struggle in humanities had secured well-paying jobs and were at the top of things. The other reason advanced for career change was pressure from close relatives. Women at times have to succumb to pressure to change their careers because they are compelled by close, male relatives. Finally, the feeling that in mathematics, one is not able to work well with other people as compared to social sciences informed the decisions to leave mathematics. One responded was categorical: "I like it and I think I realized that I like working with people because when you are in management, you really work with people, you coordinate, you…you bring people together". It is this feeling that creates the assumption that careers in mathematics are lonely and therefore people seek to move on and socialize in other careers.

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