Participation of women in mathematics at the university level

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This is a report of a study of the participation of women in mathematics at the university level. Three hundred and ninety–seven (397) women studying mathematics in four public universities in Ghana responded to a structured questionnaire on what factors made them decide to study mathematics at the university level as well as what careers they would follow at the end of their courses. The questionnaire was also used to collect the participants' perception on the low participation rate of women in mathematics at the university level. In addition to the questionnaire data, twelve women were interviewed in detail about their decision to study mathematics. Analysis of both quantitative and qualitative data revealed that, apart from the women's perceived self confidence and high ability in mathematics, fathers influenced the women most to study mathematics at the university level. The women were least influenced by male or female role models in mathematics. The majority of the women opted to become teachers at the end of their courses and only a tiny minority considered engineering or technology as a career. Finally, the participants attributed the low participation rate of women in mathematics at the university level to the 'dryness' of the subject. The implications of the findings are discussed.

Introduction

Mathematics occupies a privileged position in the school curriculum, not only because the ability to cope with more of it improves ones chances of social advancement (Fletcher, 2007), but because it is a core subject which every learner is required to study at least up to secondary school level to enable them progress beyond that level. Indeed, from computational skills to high level problem solving, mathematics is increasingly becoming a prerequisite for full participation in a technical society. Yet, mathematics is often used as a critical filter and a gate keeper for further studies and employment and the inequity that characterises the use of mathematics in this manner has attracted comments from many commentators. For example, Fazackerley and Chant (2008) observe that students may be unknowingly ruining their chances of getting into a leading research university by avoiding the study of mathematics in their choice of A-level subjects. According to the authors, at Oxford University more students were accepted in 2007-08 with Further Mathematics A-level (711) than Accounting, Art & Design, Business Studies, Communication Studies, Design & Technology, Drama/Theatre Studies, Film Studies, Home Economics, ICT, Law, Media Studies, Music Technology, Psychology, Sociology, Sports Studies/Physical Education and Travel & Tourism A-level combined (overall 494 of these subjects were accepted)(Fazackerly and Chant, 2008, p.1)

Thus mathematics learning is important for all students in any society and full participation in that society should not be predetermined by gender, socio-economic status, or any other arbitrary factor.

During the 1970s and 1980s, the focus of work on gender and equal opportunities in mathematics learning was centrally on girls. It was girls who were seen as not achieving and research showed that career expectations and subject choices were structured in such a way that boys chose careers which were different from those that were preferred by girls (Sharpe, 1976; Deem, 1980; Griffin, 1985). Many authors have argued that there are aspects of a hidden curriculum that contributed to the reinforcement of sex roles (Fennema, 1996) and that girls were not given the same opportunities as boys when it came to teacher attention and use of resources in the mathematics classroom (Mahony, 1985). Equal opportunity initiatives focused on confronting these issues, on new textbooks and language conventions to reduce gender bias, on analysing classroom dynamics and interactions, on a common curriculum to attract more girls into science, technology and mathematics (Myers, 2000).

In the 1990s, while many researchers reported lower mathematics achievements for girls than boys, (for example, Maqsud and Khalique, 1991; Randhawa, 1991; Eshun, 1999), others reported that gender differences in mathematics achievements had declined, especially in the developed world. For example, Fennema (1995) observed that gender differences in mathematics in the USA was decreasing although she added that gender differences in mathematics still existed in learning of complex mathematics, personal beliefs in mathematics and career choice that involves mathematics. She argued that gender differences in mathematics varied by socio-economic status and ethnicity, by school and by teacher. The author felt that teachers tended to structure their lessons to favour male learning and suggested that "interventions could achieve equity in mathematics" (p.26).

Over the past ten years or so, researchers have been concerned over the fact that considerably more men than women are pursuing mathematics majors and have searched for explanations why gender appears to be a significant factor in pursuing a mathematics degree (see Haines and Wallace, 2002, for example). A number of gender studies in sub-Saharan Africa (e.g. Asimeng–Boahene, 2005) have found gender differences in achievement in mathematics and science and have attributed these to sex-stereotyping in Africa which encourages boys to study science and mathematics and encourages girls to study home economics and child care (Mutemeri & Mygweni, 2005). Forkpa (2009) recently found that in spite of attempts by the Liberian Government to encourage girls to study mathematics and science, enrolments onto mathematics related courses in Liberian universities are skewed in favour of male students.

Gender inequity in mathematics education in Ghana

Various Ghanaian governments have implied a correlation between skills in science, technology and mathematics and prosperity and universities have been urged to promote science as a problem solving tool. Specifically, the last government run by the New Patriotic Party adopted science and technology as a vehicle for national development. It developed a national science and technology policy document in line with the government's Vision 2020. As mentioned above, the basic objectives of the Vision 2020, among others, is to seek to master science and technology capabilities,

and to develop infrastructure, which will enable industry and other sectors of the economy to provide the basic needs of society.

As highlighted below, there is gender imbalance regarding participation in science, technology and mathematics education in Ghana. As a result, a number of intervention programmes aimed at achieving gender balance in the participation in science, technology and mathematics education in Ghana have been pursued for over twenty years. For example, the Ghana Association of Science Teachers (GAST) and the Mathematics Association of Ghana have directed activities towards the improvement of science and mathematics education. Both associations engage actively in the promotion of science and quantitative literacy and the improvement of high school students' interest in science, technology and mathematics education.

Ghana has 8 state and at least 11 private universities. The first three universities are the University of Ghana (UG), Kwame Nkrumah University of Science and Technology (KNUST) and the University of Cape Coast (UCC). In 1962, the three universities had a total enrolment of 4301 (Eshun, 1998). In 1981, the total university enrolment in the three universities was about 8000. Since then, there has been an explosion in enrolment figures in all Ghanaian public universities. In the academic year 1987/88, for example, admissions (not enrolment) into the public universities for that year alone were 8.675. This figure reached 11, 857 in the academic year 1991/92, and increased further to 25 660 in the academic year 1998/99. Enrolment of female students as a percentage of total enrolments in Ghanaian public universities increased from 21% in 1991-92 to 25% in 1998-99. In the 2005/06 academic year, female enrolment as a percentage of total enrolments in the same institutions had increased to 35 percent and has remained steady around this figure since 2005/06. The question is: to what extent does enrolment of women onto mathematics courses reflect the increases in female enrolment proportions in Ghanaian universities? This question is not only relevant to the present study, it will guide the latter to seek an answer to the question.

Over the years women have been under-represented in mathematics at the university level. It is argued that this is a carry-over effect from the participation of females in senior secondary school elective mathematics, a subject which is a prerequisite for studying mathematics at the degree level. Eshun (2000) had pointed out earlier that while the percentage of males who participated in elective mathematics increased significantly from 14.0% in 1995 to 34.8% in 1999 that of females increased from 4.1% in 1995 to only 13.1% in 1999. Following Trusty (2002), one can argue that the number of high school mathematics courses taken could determine one's chances of studying mathematics at the degree level.

A comparison between the proportions of undergraduate women and men in mathematics in 2000 and those of undergraduate women and men in mathematics in 2008 in Ghana shows that the numbers of women undergraduates in mathematics have increased but slowly. Although the numbers of both men and women studying mathematics have increased since 2000, the proportion of women in the population of students was still very low. At UCC for example, although women constituted 33.0% of the population in 2008, only as low as 1.5% of them were pursuing mathematics courses while men constituted 67.0% with 4.5% of them pursuing mathematics in that year.

Many non-governmental organizations in Ghana and various Ghanaian governments are increasingly recognizing the need to secure equal access for males and females in science and mathematics education. This is not surprising, for an important goal of the Millennium Declaration, which Ghana has signed up to, is the promotion of gender equity and the empowerment of women, and also the elimination of gender inequity in primary and secondary education by 2005 and in all levels of education no later than 2015. The present study was a response to a request made by the Ghanaian government to all including the academia to explore ways in which gender parity can be achieved in line with Ghana's Millennium goals (Kufuor, 2008).

Purpose of the study

The study was designed with the view to identifying:

i. sources that influence women to study mathematics at the university level in order to harness these sources to improve participation

ii. careers that women studying mathematics prefer in order to use these in career advice

iii. the perceptions of female undergraduate mathematics students of low female participation in order to investigate these further.

Research questions

With the above in mind, the following research questions were formulated following the literature on participation rates of males and females in mathematics, science and technology:

1. Who/what most/least influenced the decision of women studying mathematics at the university level to choose mathematics?
2. What career or profession do women studying mathematics intend to pursue after graduating?
3. Why is the proportion of women studying mathematics in Ghanaian universities so low?

Significance of the study

It is expected that findings of this study - by way of answers to the above questions - would help to direct the attention of a number of stakeholders in education - lecturers, teachers, parents, Ministry of Education (MOE) and Ghana Education Service (GES) – to the gender imbalance in the participation rates of men and women in mathematics education at the tertiary level in general and at the university level in particular. The study could also generate debate on the nature of interventions that may be adopted to enhance gender equity in mathematics education in Ghana.

Theoretical framework

According to Leder et al (1996), the theoretical models that influence women's choice to study mathematics at the university level include: influence of the social environment, of significant others, of culture and the context in which learning takes place as well as affective and cognitive variables. Influence has been defined as the exercise of authority and leadership to persuade others and mobilize them to follow

(Dryfoos, 1990). For example, parental influence has been identified as an important factor affecting student achievement (Miller, 1994).

Following Leder et al (op. cit) the study adopted the above psycho-social influence conceptual model focusing on the influence of the social environment and the self. The environmental variables used were the school variable (teacher, peer), the wider society (role models and family - father, mother, siblings). The learner-related variables were cognitive, such as perceived ability, perceived benefits, interest and prestige (Leder, 1992). With regard to both environmental factors and self, the focus in this study was on perceived ability as a determinant of participation in mathematics education, and the concept of mathematical self-efficacy was therefore used. Bandura (1986) sees self-efficacy as a type of personal cognition related to people's judgements of their capabilities to organise and execute courses of action required to attain designated types of performance. This concept has been applied within the field of educational research to a variety of subject domains (including mathematics) and at a variety of levels (Phan, 2000). An individual's self-efficacy beliefs are conjectured to be oriented around four core concepts: *performance experiences* - an indicator of capability based on past and current performance; *vicarious experiences* - based on competencies and informative comparison with the attainment of others; *verbal feedback* - verbal feedback from teachers or adults; and finally *physiological and affective states* - judgements of capability, strength and vulnerability to dysfunction (Phan, op. cit). The current study was set within these four concepts as each of these contributes to the individual's ability to organise and execute effective learning. As Bertz and Hackett (1983) rightly point out, an individual's judgements regarding self-efficacy can be elicited by questionnaire and the present study used a questionnaire as well as an interview schedule to identify students' perception about female participation in mathematics education at the university level.

Design of the study

The research design for the study is the descriptive-exploratory-qualitative design. Descriptive research involves collecting data in order to answer research questions concerning the current status of the subjects of the study. The aim of descriptive research is to examine an event or phenomenon and characterise it as it is in a specific context (Le Compte and Preissle, 1993). There is no manipulation of treatments or subjects; the researcher takes things as they are. Merriam (1991) states that descriptive research implies that the end product is a rich, thick description of the phenomenon under study. The present study is also exploratory in nature as the purpose of the research is to investigate and gain new insights and better understanding of the low participation rate of women in mathematics education in Ghana. The design is also qualitative as the study aims to "provide a broader version of theory than simply a relationship between variables" (Silverman, 1993:27).

Population and sample

The population for the study consisted of women studying BSc or BEd Mathematics, or any course with significant mathematics content and/or methodology, in all Ghanaian universities. However, the sample for the study was purposeful and consisted of women studying a BSc or BEd Mathematics, or any course with significant mathematics content and or methodology, in four Ghanaian public universities. These universities were selected not only because they are the first four public universities in the country and the ones which offer stand-alone mathematics

courses, but because their populations reflect the rich 'cultural' mix in Ghana. The table below shows the number of women sampled and the institutions they were selected from.

Table 1 Sampling frame

Level/University	A	B	C	D	Total
100	24	21	60	30	135
200	26	18	35	26	105
300	27	23	44	28	122
400	44	22	38	30	134
Total	121	84	177	114	496

In all, 496 female mathematics students were sampled. Out of this number, 397 (80.7%) returned their completed questionnaires. The table below shows the number of students who participated in the study from the various universities.

Table 2 Participants' universities and programmes

University/Programme	Physical Sciences (Mathematics)	Education (Mathematics)	Total
A	103	-	103
B	20	59	79
C	-	149	149
D	66	-	66
Total	189	208	397

It can be inferred from the table above that two universities A and D do not offer mathematics education courses and University C does not offer mathematics courses related to physical sciences. University C primarily trains mathematics teachers for the basic and senior high schools in Ghana. University B both trains mathematics teachers for the basic and senior high schools and offers mathematics courses as part of physical sciences programmes.

Method

Three hundred and ninety-seven (397) participants responded to a structured questionnaire (administered by Teaching Assistants in the four universities who had been trained by the author for the purpose) on what factors decided them to study mathematics at the university level as well as the careers they would follow at the end of their programme. The questionnaire was also used to collect participants' perceptions on the low participation rate of women in mathematics at the university level. The structured questionnaire was made up of two parts. Part A was the preliminary for obtaining general statistics like the university, level of students, among others. Part B was made up of 10 questions. Item 1 was used to obtain data on the profession the subjects hoped to follow on completing their courses. Item 2 to 9 were meant to measure the respondents' perception about the low rate of participation in mathematics at the university level. Item 10 was used to identify and measure the sources that influenced women studying mathematics at the university level to study the subject.

These sources included teachers, mothers, fathers, peers and siblings (as environmental sources) and perceived ability, as well as perceived benefit of studying mathematics such as good mathematics–related career and prestige. Ten factors were identified from the literature and respondents were required to rank these in order of perceived importance. Thus the factor ranked 1 had the greatest influence and the one ranked 10 had the least influence. An operational definition was adopted for measuring the 'strength' of the sources - the source that was seen as having the greatest influence was given a score of 10 whilst the least influence was given a score of 1.

In addition to the questionnaire data, 12 women (3 selected at random from each university) were interviewed in detail about their decision to study mathematics. An open ended interview schedule made up of 20 items was used. The interview schedule was made up of four parts covering *pre-university education*, *perception of mathematics*, *university education and mathematics* and *gender*. The purpose of the interview was to probe further the interviewees' questionnaire responses on factors that influenced them to select mathematics at the university as major and their perceptions of both mathematics and the low participation rate of women in mathematics at the university. Both questionnaire and interviews data were collected between March and May 2008.

Results

On the survey instrument, sources of influence were ranked by the respondents in order of importance as follows:

1. Ability to do mathematics (ATDM)
2. Fathers
3. Teachers
4. Interest
5. Mathematics- related career (MRC)
6. Mothers
7. Peers
8. Prestige
9. Siblings
10. Role-models (RM)

Overall, the source selected as the greatest influence and ranked 1 *most* by the respondents from the various universities was ATDM whilst the sources that was selected as the least influence and ranked 1 *least* by the respondents was RM. The table below gives details of the sources that were selected as the *greatest* influence and ranked 1 by the respondents from the various universities.

Table 3 Frequencies of sources of influence

Source (with rank) / University	A	B	C	D	Total
• ATDM	29	15	20	23	87
• Fathers	27	13	20	16	76
• Teachers	5	18	28	2	53
• Interest	7	15	14	3	39
• MRC	21	3	1	8	33
• Mothers	3	4	16	4	27
• Peers	6	3	11	5	25
• Siblings	2	2	13	3	20
• Prestige	1	2	16	1	20
• RM	2	4	11	1	19
Total	103	79	149	66	397

In addition to the frequencies showing the number of respondents who selected the various sources as the greatest influence, each source was given a weighted score showing the mean of the individual scores awarded to the resource by the respondents. The means scores ranged from 1 to 10. A greatest mean score for a source of 10 would indicate that every respondent selected the source as the one with the greatest influence, whilst the least mean score of 1 for a source would indicate that every respondent selected that source as one with the least influence. Table 4 below shows details of the weighted mean score of the sources.

Table 4 Weighted mean scores of sources of influence

Source (with rank) / University	A	B	C	D	Overall mean score
1. ATDM*	8.4	7.2	6.4	7.9	7.3
2. Fathers*	8.1	7.0	6.0	7.8	7.0
3. Teachers*	4.1	6.5	6.8	4.0	5.6
4. Mothers	6.2	4.7	5.9	5.3	5.6
5. Prestige	4.4	6.0	6.0	5.5	5.5
6. Peers	5.1	5.3	5.8	5.0	5.4
7. Siblings	4.8	5.6	4.7	5.0	5.0
8. Interest	4.2	5.8	4.9	4.2	4.8
9. MRC	6.6	2.9	4.0	6.1	4.8
10. RM*	3.3	4.0	4.6	4.0	4.0

* No change in rank using weighted mean scores

It can be inferred from Table 4 that when all the rankings by the respondents were taken into account, there were no changes in the ranks of *ATDM, fathers, teachers* and *RM.* Thus, respondents' perceived ability to do mathematics was consistently seen by them as the greatest influence when it comes to deciding to study mathematics at the university level. Another source that was also consistently seen as an important source was the fathers' influence. The position of teachers as a source of influence did not change after weighting the scores but the weighting suggested that mothers had as much influence as teachers although more respondents selected the latter as their first source of influence than they did select mothers. It is important to observe that the

weighted mean scores for teachers were relatively lower in Universities A and D. This is an interesting finding because Universities A and D do not offer mathematics education as a subject and perhaps this influenced the respondents' perception about teachers as an important source of influence when it comes to deciding to study mathematics at the university level. Another interesting observation is that (female or male) role models as a source of influence remained the least important source of influence when the weighted means were used. The implications for education of the above findings especially those regarding *teachers* and *role models* (in mathematics) are discussed in a later section.

Regarding the careers or professions women studying mathematics intend to pursue after graduating, the table below gives details of the careers the respondents were intending to follow.

Table 5 Distribution of respondents' professions of interest

Profession /University	Number of respondents				
	A	B	C	D	Total
2. Actuarial Science	17	6	-	25	48 (12%)
3. Business -related	63	10	46	33	152 (38%)
4. Engineering	17	3	-	8	28 (7%)
5. Teaching	5	53	103	-	161 (41%)
6. Other	1	7	-	-	8 (2%)
Total	103	79	149	66	397 (100%)

Of the 397 respondents, 41% aspired to join the teaching profession, 38% said they would like to pursue business-related careers like banking, insurance, and other commercial activities. Only 12% were considering actuarial science and only 0.7% hoped to become engineers. The results presented in Table 5, provides an answer, even if temporary, to the Research Question 2 which sought to find out the professions women studying mathematics intend to pursue after graduating and indeed, the interview data presented in a later section supported both the findings regarding sources of influence and those about respondents' preferred careers.

Regarding the participants' perceptions of the low participation rate of women in mathematics, the following reasons were given by the respondents:

- Mathematically talented girls are less interested than equally talented boys in mathematics-related careers.
- Mathematics is a 'dry' subject – not much can be done with it apart from using it to the next level in education
- Fewer women than men see the demanding nature of mathematics major as a positive feature, a source of status or of interest and motivation.
- Lack or loss of interest in mathematics by most girls.
- Belief that there are easier majors which would hold the interest of female students.
- Lower preference for mathematics by women.

- Poor teaching of mathematics.
- Feeling overwhelmed by the pace of the workload in mathematics programmes.
- Women tend to rate their ability and the personal importance of mathematics lower than their male counterparts do.
- Different roles by men and women in the Ghanaian society.
- Lack of information about the career opportunities with a degree in mathematics.
- Lack of role models
- View that mathematics is too difficult, time consuming and has limited economic benefits.

Interview data

As mentioned above, 12 of the participants were interviewed in detail about their responses to the questionnaire data. The 12 interviewees were given the following codes: N, P, Q, R, S, T, U, V, W, X, Y, Z. Interviewees N, P, Q were from University A; R, S, T were from University B; U, V, W were from University C; and X, Y, Z were from University D. It is worth reiterating that Universities A and D do not offer mathematics education programmes, whilst University C offers only mathematics education programmes. University B offers both physical sciences-related mathematics and mathematics education.

The women were asked questions about their interest and ability in mathematics at the pre-university level and how they were influenced to study mathematics. All the interviewees thought they had a lot of self-confidence and interest in the subject and these qualities showed up when they were in the primary school. Apart from their own ability to do mathematics, the respondents were influenced most by their father who paid for extra tuition in mathematics when they were in the basic school. When asked to talk about their experiences in mathematics, N said:

> I have had interest in mathematics and I was confident doing maths since my primary school days. I enjoyed doing maths in the JSS (junior secondary school) as well. My father always said maths helped in everything so I was determined to study it to the highest level. I had a very good private teacher who came to my house twice a week……

It would appear that although N admitted that her private teacher was good, she still felt her father was the greatest influence.

R who is training to become a mathematics teacher remarked:

> I know I want to become a teacher but I wouldn't say that my teachers made me decide to become a teacher…I'll say it was my father who encouraged me to do maths….in my time, the boys were the ones who did so well in maths…it's not like now that many girls are doing elective maths…elective maths was for the boys….I remember my core (mathematics) teacher saying one day that he would encourage all of us ….boys and girls…to do elective maths but the girls were not confident. I was very confident and knew I would do elective maths even when I was in the JSS (junior secondary school). My father encouraged me to do maths so that I would teach maths…

Interviewee R, like interviewee N, was full of praise for her father who encouraged her to do mathematics. Also like N, she had private tuition but did not see her own father as a teacher although he was a teacher by profession. Again, R compared the support she got from her father with that she got from her teachers and concluded that her father was the greatest influence.

Interviewee W was also training to be a teacher and she said this about her teachers and herself:

> I would say myself and my teachers…I would say my teachers influenced me most… well, I was doing only core maths with physics, chemistry and biology at SSS (senior secondary school) at the beginning…. but based on my grades in most of my subjects, my teachers advised me to register for elective mathematics and I did that on remedial basis and I had grade B….this grade encouraged me so I decided to study BEd Mathematics…it's a good course and I am confident that I will be a good maths teacher…

Interviewee W was very positive about her teachers and saw her senior secondary school teachers as role models. She attended a girls' school and this perhaps made a difference about her views about teachers. As discussed below, there is literature which seems to suggest that females in single-sex school achieved slightly higher than counterparts in mixed schools. If girls in a single-sex school do well in mathematics, then there is the likelihood that they will attribute their achievement in mathematics to the work of their teachers. W's decision to become a mathematics teacher was based on her self-confidence in mathematics as well as the way in which she was encouraged by her teachers.

On the question of career choice, Interviewee Z, who was studying statistics as part of a business studies programme said she loved to do mathematics because of her parents' background. Her father is an accountant and her mother works for the Ghana Statistical Services. Z would like to work in bank and thought her father made her love mathematics. She said:

> Dad encouraged all his children to do science. We all liked maths as it is part of science in a way…without maths, science would be difficult…we all liked maths from primary school…and we had a private tutor too…and we did maths everyday at home with our private tutor. Dad would make sure we returned from school on time so that we could do our homework with the private teacher…I would say my dad was the greatest influence because he understood education and put his money where his mouth was…

Z also saw her father as the greatest influence as he thought mathematics would help his children to reach their goals in life. In all the interviews, participants from universities which did not offer mathematics education saw the contribution of teachers differently from those from universities which offered mathematics education. Interviewees from the latter saw teachers in much more positive light than their counterparts from universities which did not train teachers. This finding has very important implication for education as it seems to draw a line (not necessarily a fine one though) between mathematics and mathematics education in Ghanaian universities.

Another finding that confirmed the respondents' view about role models was the respondents' lack of knowledge of any female role models in mathematics in Ghana or elsewhere. In an answer to whether she knew any role models in mathematics, Y said:

> No, I don't have any knowledge about them, but I was taught mathematics by a woman at the SSS… she actually inspired me a lot… this teacher could teach with high level of confidence… you could really see that she was so good and knew what she was about when teaching…. I remember she was the only woman among the men teaching mathematics in my school…. I was so fascinated by the way she taught with high level of confidence as well as competence…

Interviewee V was in her final year on the BEd Mathematics programme and she seemed to have read about women in mathematics education. She said:

> Most of those that I know are men. There is no female professor of mathematics in Ghana. Even all the lecturers in the mathematics education department are men….no…. I don't think we have any role model…

In spite of the apparent lack of female role models, all the twelve women interviewed were emphatic about their view that mathematics is not for men alone. Some of the interviewees were of the view that one would need special aptitude and ability to study mathematics due to the critical thinking and reasoning that are associated with the study of mathematics and thought women too possessed these qualities. About how they rated women's 'ability' in mathematics as compared to that of men, the majority of them thought, in general, male mathematicians tend to be better at mathematics than female mathematicians. However, comparing their own ability to that of the men, they claimed to be working at the same level as their male counterparts.

They thought the reasons for the low participation rate of women in mathematics had nothing to do with ability. All the women interviewed claimed that the low participation rate was the 'fault' of some teachers in the senior secondary schools. They thought the subject was presented as a 'dry' subject which had to be passed to enable one to progress from one level of education to the other. The interviewees gave various reasons for the low participation rate and all these reasons seemed to buttress the so-called 'dry' image of the subject. For example, Interviewee P said:

> Maths is simply dry…. that's why many women don't do it...they just don't know what they will do with it…. some of the girls did not get any advice about the uses of maths….

Interviewer T shared the above view and thought if students knew everything involved mathematics they would do elective mathematics and pursue mathematics degrees. She remarked:

> As for maths, we all know it is 'dry' unlike subjects like business or science that one can find many uses in real life for…maths is difficult so to do it, one must be disciplined and have time… I think many girls find it too difficult at the SSS level and that's why only a few of us are doing it in the university now…

In the view of nearly all the interviewees, the utilitarian value of mathematics is not stressed well enough in school so girls do have the full range of the careers they can pursue in mathematics. This is an important finding and it would appear that the present junior and senior secondary mathematics curricula will have to be examined carefully to sees how much the utilitarian value of mathematics is espoused in them.

Discussion

The analysis of both quantitative and qualitative data collected for the study has shown that the respondents' perceived ability as well as their self-confidence in mathematics is the greatest source of influence when it comes to deciding to study mathematics at the university level. Fathers constitute the second most important source of influence. Most of the women interviewed acknowledged the financial support they received from their fathers and attributed their success in mathematics to that support given in the form hiring private tutors to provide one-to-one tuition in mathematics. The women were least influenced by male or female role models in mathematics. The majority of the women opted to become teachers at the end of their courses and only a tiny minority considered engineering or technology as a career. Also, the participants attributed the low participation rate of women in mathematics at the university level to their low perceived utility of mathematics. The above findings are discussed below.

Firstly, some of these findings are somewhat surprising as they seem to contradict the findings of earlier relevant research on gender and mathematics education. For example, regarding women's self-confidence in mathematics, many researchers have found that women's expectations for success in mathematics, their self-confidence, and their self-efficacy in their mathematics abilities are often low (Betz & Hackett, 1983; Lapan, Shaughnessy & Boggs, 1996). Having said that, it is important to point out that the women who took part in the study did not believe in any stereotyping at all. They believed they had the ability to study mathematics to any level. The absence of stereotyping on the part of the women could explain their high self confidence and perceived ability in mathematics. According to Steele & Aronson (1995), stereotype threat is the fear of confirming a negative stereotype about one's own group. According to the theory, whenever a woman engages in a mathematics task she faces the possibility of confirming the stereotype of women's low mathematics abilities if she fails to perform the task well (Spencer et al, 1999). Empirical research has demonstrated that women under-perform relative to their male counterparts when stereotype threat is present. However, when stereotype threat is removed, the gender gap disappears (Spencer et al, op. cit; Dar-Nimrod, 2006).

Even so, it would appear that the low participation rate for women studying mathematics at the university level is in part due to stereotyping. Thus, although the women who took part in the study did not exhibit any signs of inferiority when it comes to studying mathematics (possibly because they are already studying the subject at the university level), they conceded that most of their colleagues who are not studying mathematics see the subject as a male domain. This situation is hardly surprising because according Eccles' model on stereotyping (Eccles, 1994), which described a person's expectations to succeed and the subjective value of a domain, if women do not expect to succeed and place relatively little value on mathematics, then they will not choose to take advanced courses in mathematics-related fields.

Secondly, the findings regarding the influence of parents and other persons (including peers), seem to confirm earlier research findings. On the positive side, family support and encouragement play a part in the woman's choice to study mathematics at the higher level. According to Fabricant, Svitak and Kenschaft (1990) all the 22 black women with a doctoral degree interviewed by Kenschaft reported that they had supportive family members who were willing to sacrifice for their education based on

the recommendation of the girls' secondary school teacher who told them they were gifted in mathematics and needed to encourage them. The women who saw their father as the greatest influence regarding their decision to study mathematics at the university level mentioned the financial sacrifices their parents, particularly their father (who in most cases was the breadwinner), made to help them to develop their interest in mathematics as well as confidence in themselves so that they would be able to study the subject at university level.

A number of researchers and commentators have observed that women are under sociological (including gender role socialisation) and cultural pressure (including peer pressure) not to pursue degree in mathematics (Leslie et. al, 1998). Parental pressure on women also plays a significant role (Dick and Rallis, 1991). According to Seymour (1995), some women simply cannot bring themselves to think of choosing mathematics as a major subject. On peer pressure, including pressure to please men, Seymour (op. cit.) observes that some men have the tendency to see physical attractiveness and intellectual capacity as mutually exclusive qualities in women who choose mathematics majors (p.453) and this is a problem for women. Women's negative experiences with mathematics teachers, including lack of female role models, and dislike for the atmosphere in mathematics classes also constitute a problem which can dissuade women from studying mathematics at the university level (ibid). It must be pointed out that at least one of the interviewees drew a link between school type and mathematics achievement when they stressed that they attended a girls' school. This observation seems be line with the literature which suggests that single-sex schools help girls to learn mathematics.

Thirdly, the findings regarding women's choice of career can be explained in terms of psychological factors, including one's value system. Lackland and De Lisi (2001) have observed that more women than men believe that what is really important in life is helping each other, and careers commonly labelled in the helping professions (e.g., nursing and teaching) are a better fit for this value system. In other words, fewer women than men think that being a mathematician contributes to what really matters in the world (Lackland and De Lisi, op. cit). This observation could in a way account for the low participation rate for women in mathematics at the university level in Ghana.

Finally, the present study corroborates the findings of other similar studies, that women's experiences are an important aspect of their mathematics-related decisions (Grevholm, 1996). Women who have negative attitudes and expectations of success, are exposed to negative stereotypes and are discouraged from doing mathematics. Heine and Dar-Nimrod (2006) found that women who were reminded of the stereotype about female mathematics underachievement performed worse in a mathematics test than those who were encouraged that there is no sex difference in mathematics. The implication is that as, Fennema (1995) rightly points out, "interventions can achieve equity in mathematics education" (p.26).

Conclusion

This paper has presented some results from a study which sought to investigate the factors that motivate women to study mathematics at the university level. The study has shown that the most motivating factor which influences women to study mathematics in Ghanaian universities is their perceived ability in the subject. This is

hardly surprising as self-efficacy has been found in many studies to correlate positively with achievement. This main finding regarding the greatest source of influence for women studying mathematics at the university level leads to some preliminary conclusions.

Firstly, female students who are admitted to the BSc mathematics and BEd Mathematics courses have, on average, good previous experiences of mathematics in terms of their achievements. This does not just imply grades gained in the senior secondary mathematics examination, but is the author's personal view of the level of confidence and knowledge they exhibited during the study as well as their attitudes towards the subject generally.

Secondly, BSc Mathematics students seem to have had significantly better vicarious experiences which relate to the extent to which they have (or have not) had support from their teachers, parents (particularly their father) and other persons. These positive experiences made many of them decide to select the BSc course which they believe would open more doors than the BEd course. One could argue that this is important in that, if such students are mixed with BEd students for purposes of mathematics teaching (in modules that are common to both groups), then this could weaken the self-efficacy in BEd students as they establish their mathematical abilities in relation to the BSc students in the class. Therefore, in teaching both groups, it would seem appropriate to suggest that support groups need to be encouraged among similarly skilled students through group work and practical projects so that vicarious experience can be seen as positive by all students.

Thirdly, both the BSc and the BEd groups seem to care about the low participation rate of women in mathematics at the university level and would want to see programmes that would encourage more women to study mathematics at the university level. Naturally, some students may love the subject if it was taught differently and others may still be worried about it, but all the students interviewed thought a lot could be done by teachers to improve the image of the subject by using interactive and 'student friendly' methods as well as highlighting the utilitarian value of mathematics in their lessons.

Finally, female students do have motivation to improve their mathematics and teachers, especially those in secondary schools, need to get to know students to see which type of support and encouragement would be best for individual students. More importantly, teachers of mathematics need to design strategies that will improve the self-efficacy of girls in both junior and senior secondary schools. A study investigating the factors that influence girls in senior secondary schools to choose elective mathematics could go a long way to provide more insights into "how to catch them young"!

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