A Psychological Study of Mathematics Attitudes and Achievement among Female Ivorian Students

by

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Abstract: Researchers from diverse fields continue to search for clues underlying the disparity between interest and achievement of men and women in mathematics. In Western countries, psychologists have focused on such factors as attitudes and motives when studying women's mathematics achievement. Relatively little attention has been placed on women in sub-Saharan countries. For this study, one hundred and forty female students in Cote d'Ivoire have completed an inventory of mathematics attitudes (the Fennema-Sherman Mathematics Attitudes Scale, 1976), and a background questionnaire. High-achieving female students report less anxious attitudes, more positive attitudes towards problem solving (effectance motivation), and more positive attitudes towards the usefulness of mathematics than do low-achieving students. In conclusion, this study discusses future research and intervention strategies to positively affect mathematics attitudes and achievement for female Ivorian students.

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The reality of the gross under-representation of sub-Saharan African girls and women in science, mathematics, and technology (STM) fields is unsettling. The problem for Ivorian girls and women mirrors the situation found in other sub-Saharan African countries. According to educational statistics, in 1986 women represented fewer than 5% of Ivorian students at the third level enrolled in the fields of natural or computer sciences, medical sciences, mathematics, and engineering.[1] For African women, overall, the enrollment figures are somewhat better: 21% of students in mathematics and computer science and 6% of students in engineering were women (Schmittroth 1991). Nonetheless, the fact remains – women still have not attained educational equity in many African countries, and they are systematically under-represented in scientific and technical disciplines at universities (Adams and Kruppenbach 1986). In a number of African countries, women's enrollment in science-based training and their involvement in science-based professions are among the lowest in the world.

In the non-compulsory school system of sub-Saharan Africa, a variety of factors are believed to deter female access and achievement, specifically in STM fields (Johnston 1992). Studies from more than a decade ago suggested that one or more of the following factors served as obstacles to girls' education: parents' negative attitude towards the education of their daughters, a shortage of female teachers to serve as role models, an early marriage age for females, the demand for girls' household labor, and national educational policies that differentially affect the sexes (United States Agency for International Development 1982). It is unclear whether these variables continue to restrict females' access to, and achievement in, education today. Several explanations might account for our failure to more confidently articulate the role these factors play. The most compelling of these is insubstantial documentation of educational studies conducted with African samples.

Methodological, substantive, and statistical problems plague many such studies. At the workshop on "Science, Technology and Mathematics Education," organized by the Women Education

Unit of the Ministry of Education in Nigeria (November 20 - December 2, 1987), a good number of papers focused on the problem of females' under-representation in the above- named fields. Common to most papers at the workshop was a dearth of discussion about methodological and statistical tools that authors used. Instead, audience members were presented with general or global descriptions of the possible factors affecting science, technology, and mathematics education of Nigerian girls and women. This deficit of empirical data makes it difficult to arrive at confident conclusions concerning factors affecting women's education.

In addition, there is insubstantial documentation regarding the impact that psychological and familial variables have on access and achievement for African girls and women in STM education. Adams and Kruppenbach state, "Unfortunately, in the UNESCO reports and the sector studies of the World Bank and US-AID there is insufficient information about the factors that might be thought to influence the in-school attainment of students… At the same time, the inadequate treatment of in-school factors that influence equity is a conceptual weak spot reflecting the fact that sector assessment methodology is still in an early stage of development" (1986:11). With the exception of the Ghana Commonwealth Africa Regional Workshop held in Accra (January 1987), and the National Workshop on Promoting Science, Technology, and Mathematics among Girls and Women held in Lagos, Nigeria (November 1987), there have been no recent systematic attempts to explore these issues in sub-Saharan Africa.

Study Objective

The purpose of this exploratory study was to investigate the impact that several components of mathematics attitudes have on mathematics achievement in Ivorian female middle and secondary school students.

As a result of the limited data available in this research area, this analysis had a twofold objective: first, it pilot tested a psychological tool, the Fennema-Sherman Mathematics Attitudes

Scale (1976), within an African context (initial construction and validation of the scale included exclusively Euro-American samples of secondary school students). Second, it aimed to contribute and expand the existing database of empirical studies addressing psychological components of achievement using samples of African girls and women.

In contrast to the lack of empirical data for Africa, a significant body of research exists on Western women. The Fennema-Sherman Mathematics Scale is one of the most widely used and replicated psychological measures assessing attitudinal components related to mathematics. Reviewing the many studies that utilize this scale is beyond the scope of this study. It is, however, important to note that numerous studies demonstrate the importance of factors such as confidence (Fennema and Sherman 1978; Meyer and Koehler 1990); sex-role stereotyping of mathematics as a masculine domain (Baker 1983; Boswell 1985); and belief in the importance of mathematics (McLeod 1989). In their review of literature, Frazier-Kouassi et al. (1992) found that most studies testing factors that inhibit or enhance women's performance in mathematics and physics are characterized by cross-gender comparisons. Yet, few focus on different sub-groups of female students (Sherman 1982, 1983), as does the present study.

The challenge of this study has been to use the Fennema-Sherman Mathematics Scale to unravel complexities underlying the low representation of Ivorian girls and women. Within the socio-cultural context of sub-Saharan Africa, it is expected that some results will differ from those found in Western samples. The challenge, then, becomes to attempt to examine these differences, given the unique socio-cultural realities of Cote d'Ivoire. Furthermore, these differences have implications for designing culturally appropriate interventions for Ivorian girls and women, rather than "borrowing" from existing Western interventions – which may or may not be relevant or effective for the sample population.

Literature Review

In the following section, a brief review of the few available relevant studies on African girls and women is presented.

An individual's perceived ability to do well in a subject is one variable that has received considerable attention in psychological literature considering American females. Within an African context, Lee and Lockheed (1990) conducted a study of 1,012 students enrolled in single-sex and mixed-sex secondary schools from ten Southern states in Nigeria. The authors found that perceived ability positively related to higher achievement in mathematics. Similarly, in a study of secondary and college students selected from seven state secondary schools and one federal college in Nigeria, Aghenta (1989) found that "perceived difficulties of science occupations" was a significant factor in preventing girls from entering STM fields. The attitude that one holds towards mathematics or science appears to be a powerful predictor of achievement in the respective fields. A prior positive attitude towards STM (Aghenta 1989), the development of a positive attitude towards STM by a teacher (Mordi 1991), or a strong positive attitude toward science (Akpan 1986) all appear to play a critical role in whether African women will persist or drop out of the STM pipeline. In her study of secondary students, Aghenta (1989) found that a poor attitude towards STM was a barrier to access of STM fields. Conversely, she found that a good or positive attitude was one of several factors that facilitated performance in STM. Eshiwani (1983) reported that girls in Kenya generally have negative attitudes towards math and these attitudes tend to depress their achievement.

Generalizing from STM education to the broader context of women's education, a review of sector studies reveals a positive relationship between female education and several well-being indicators. According to King, "All of the evidence from Third World countries shows a close link between women's education and social and economic development, and between the size of the education gender gap and national development" (1990:6). The links are already well-established

between women's education and fertility, child health and survival (US-AID 1982; Bourque and Warren 1990; King 1990); formal labor force participation (OE & OWD 1990); income and wage employment (King 1990); and women's empowerment into the rights and responsibilities of citizenship (King 1990). Furthermore, the links for education in the STM fields are presumed to be particularly strong for women. Girls who become interested in, persist in studying, and then work in STM fields, significantly improve their life chances (e.g., standards of income, health, fertility, and productivity), as well as those of their family (e.g., through increased resources, and by being available as a role model for younger female kin).

Method

Subjects:

One hundred and forty Ivorian female students volunteered to participate in the study. The sample included a total of 82 students from Abidjan and 58 students from Abengourou and Ebilassakro, Cote d'Ivoire. Abidjan, a major metropolitan area, represented the urban sector, while the villages of Abengourou and Ebilassakro represented the rural sectors for the study. Students participated without payment.

Students ranged in age from 10 to 22 years, with a mean of 13.49 years. The school level range for students was from "CM2" [2] to "1ere" [3]; the modal grade level was "4eme."[4]

Procedures:

Two Ivorian female research assistants (a University and a secondary school student) distributed and collected the questionnaires in the summer of 1993. The research assistants selected helped to ensure that participants completely understood the directions of the questionnaire, and served to reduce cultural bias on behalf of the researcher (a non-Ivorian). All available female students in Ebilassakro received a questionnaire. A summer school program at one of the "lycees" (a secondary school) in Abengourou granted permission for the research assistant to distribute the

questionnaire to all female students enrolled in the math course. Female students enrolled in a summer school located in the subdivisions of Abidjan (Adjame, Cocody, and Yopougon) received questionnaires.

Materials:

Respondents completed a questionnaire consisting of the Fennema-Sherman Mathematics Scale (F-S MAS) and several background questions. The F-S MAS is a 108-item multi-dimensional self-rating scale that includes an equal number of positively and negatively weighted attitudinal statements for all of its subscales. The instrument requires approximately 30 minutes to administer. Each subscale yields a maximum score of 69 points, with each of the 12 items being rated on a 5-point Likert scale with options ranging from "strongly disagree" to "strongly agree."[5] Elizabeth Fennema and Julia Sherman originally developed and validated the scale, whose use is widespread in gender studies of mathematics attitudes and achievement. It was necessary to translate the F-S MAS from the original English version to French to suit the present sample of Francophone students. A professional translator completed the translation.

The F-S MAS includes the following subscales: attitudes towards success in mathematics (AS); mathematics as a male domain (MD); mother (M); father (F); teacher (T); anxiety (A); effectance motivation (E); confidence (C); and usefulness (U) as described in more detail in the following paragraphs. In this study, the confidence subscale was not administered.

The Attitude toward Success in Mathematics Scale (AS) is designed to measure the degree to which students anticipate positive or negative consequences as a result of success in mathematics. They evidence this fear by anticipating negative consequences of successes, as well as lack of acceptance or responsibility for the success, e.g., "It was just luck" (Fennema and Sherman 1976).

The Mathematics as a Male Domain scale (MD) is intended to measure the degree to which students see mathematics as a male, neutral, or female domain in the following ways: a) the relative

ability of the sexes to perform in mathematics; b) the masculinity/femininity of those who achieve well in mathematics; and c) the appropriateness of the study of mathematics for the two sexes (Fennema and Sherman 1976).

The Mother (M) and Father (F) scales are designed to measure students' perceptions of their mother's/father's interest, encouragement, and confidence in their ability to do mathematics. It also measures the student's perception of their mother's/father's example as an individual who is interested, confident, and aware of the importance of mathematics (Fennema and Sherman 1976).

The Teacher scale (T) is designed to measure students' perceptions of their teachers' attitudes toward them as mathematics learners. It includes a measure of teachers' interest, encouragement, and confidence in the student's ability (Fennema and Sherman 1976).

The Mathematics Anxiety scale (A) is intended to measure feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics. The dimension ranges from feelings of ease to those of distinct anxiety. The scale is not intended to measure confidence in the student's ability (Fennema and Sherman 1976).

The Effectance Motivation in Mathematics scale (E) is intended to measure effectance (or problem-solving) as applied to mathematics. The dimension ranges from lack of involvement in mathematics to *active enjoyment* and seeking of challenge. The scale is not intended to measure interest or enjoyment of mathematics; rather, it attempts to measure attitudes towards the enjoyment of mathematics (Fennema and Sherman 1976).

The Mathematics Usefulness scale (U) is intended to measure students' beliefs about the usefulness of mathematics currently, and in relation to their future education, vocation, or other activities (Fennema and Sherman 1976).

Grades received in mathematics during the 1992-93 academic year measured students' academic achievement. Students self-reported their grades and the researcher computed the average

from this data. The grading scale used in the Ivorian educational system ranges from 0 (lowest) to 20 (highest).

Students responded to additional questions ascertaining the source(s) of encouragement and assistance at school and home, and their class year during the 1992-93 academic year.

Results

Several independent group t-tests were performed to test for significant differences between various groupings of the students. There was a significant difference between the mother subscale scores for the urban students (M = 29.19) compared to the rural students (M = 34.14). Rural students had significantly more positive mother scores than the urban students ($t = -2.39$, $df = 136$, $p = .018$, two-tailed). No further significant differences were found among the two groups for the remaining F-S MAS subscales.

Second, independent group t-tests were conducted to measure younger students versus older ones. Students ages 16 or younger comprised the younger group, and students ages 17 and older comprised the older group.[6] There was a significant difference between the older and the younger students on the male domain subscale ($t = 2.56$, $df = 136$, $p = .012$, two-tailed). The older students had more positive male domain attitudes (M = 41.69) than the younger students (M = 37.57). No additional significant differences among the two groups for the remaining F-S MAS subscales were found.

Third, independent group t-tests were conducted with the following groups: students who had achieved an average grade of 10.0 or lower in mathematics (low-achieving), and those who achieved an average grade of 10.1 or higher (high-achieving). Several significant differences emerged between the two groups. A significant difference was found for the groups on the anxiety subscale ($t = -4.39$, $df = 136$, $p = .000$, two-tailed). High-achieving students had higher positive scores on this subscale. The two groups differed significantly on the effectance subscale ($t = -3.02$, $df = 136$, $p = .003$, two-

tailed). High-achieving students had more positive effectance scores. The third and final significant difference was found on the usefulness subscale ($t = -2.26$, $df = 136$, $p = .026$, two-tailed). High-achieving students had more positive usefulness scores.

Discussion

Several African authors suggest that overall attitudes are partially responsible for girls' low or poor participation in mathematics and science (Akinnuli 1982; Onobowale 1982; Oyedonkun 1983; Aghenta 1989; Bajah and Bozimo 1989; Osibodu 1989). Yet, these authors fail to identify the specific attitudinal components presumed to have an inhibitory or enhancing effect on actual behavior. From the results of this study, apparently certain components of students' attitudes relate positively to achievement. Particularly in the area of mathematics, the relationship between attitude and ability is believed to be both dynamic and interactive. Within this context, attitudes and their respective components deserve closer examination. In this study, we attempted to critically examine specific components of attitudes towards mathematics and their relationship to achievement.

The results of the t-tests revealed significant differences between students in the high-achieving group and those in the low-achieving group. The high-achieving students reported less anxious attitudes, more positive attitudes towards persistence and problem-solving and more positive attitudes towards the usefulness of mathematics than their low-achieving peers.

In this study, a feeling of lessened anxiety towards mathematics refers to decreased feelings of dread, nervousness, and concomitant bodily symptoms associated with doing mathematics. The present findings reveal that high-achieving students reported less anxious attitudes. Thus, the students who performed better academically were those who felt more at ease and less nervous toward the subject. It is difficult to determine the exact cause of the lessened anxiety for this group. However, one can speculate that the high-achieving group may have had more positively reinforcing

experiences in the past with mathematics classes, examination, or teachers, which then acts to reduce the anxiety and fear associated with a stereotypically difficult or masculine subject.

Effectance motivation refers to a student's attitude towards the active seeking and enjoyment of the challenges of mathematics. In this study, high-achieving students reported more positive attitudes towards this sort of behavior. This finding suggests that students who feel more positive about their problem-solving abilities, who actively seek out challenges, and who are not easily discouraged by difficult problems are higher achievers in mathematics. Students who score high on effectance motivation may be more intrinsically motivated, or have a history of positive reinforcement from parents or teachers for persistence in the face of difficulty.

Perceived usefulness of mathematics was another attitudinal component that differentiated the high-achieving group from the low-achieving group of students. Previous research has found that students who perceive the utility of studying mathematics will tend to perform better in the subject (McLeod 1989). Conversely, students who fail to see the practical or future utility in studying mathematics tend to enroll less often in higher-level math courses, perform less well in math courses, or find math less than interesting than other courses.

Stereotyping mathematics as a predominantly male domain is an important variable in understanding the complexities of gender and mathematics achievement. In both Western and African samples, stereotyping mathematics may account for poor performance of girls (Fennema and Sherman 1977; Osibodu 1989). Within the West African socio-cultural context, occupational decisions frequently separate along rigid stereotypical lines with specific jobs being perceived as more masculine or feminine. These stereotypical attitudes likewise may affect students' perceptions of their ability to study certain subjects or pursue a certain career path.

It is interesting that the subscale measuring attitudes towards mathematics as a male domain evidenced significant differences only for the group divided by age. Students age 17 years or older

indicated less stereotypical attitudes towards mathematics as a field of study than the younger students did. The older group perceived mathematics to be a subject open for both males and females to pursue and achieve. The implication of this finding suggests that the more female students persist in the educational pipeline, the less stereotypic their attitudes become. Additionally, one might hypothesize that the longer girls stay in the educational pipeline, the more likely they are to challenge existing traditional ideas or beliefs based on the rigidity of gender. Likewise, the longer they stay in school, the more chances they have to be exposed to successful female role models in mathematics and other related subjects; these role models may positively affect the formation of students' attitudes. An additional interpretation of this finding suggests that students with less stereotypic views of mathematics might possess a history of successes in mathematics that in turn influences their idea of appropriateness of the subject for them as a female.

It is worth noting that the majority of the sample (44.9%) indicated they would pursue traditionally female-typed occupations, such as "teachers, librarians, and counselors" (26.3%), or "registered nurses, pharmacists, dieticians, therapists, and physical therapists" (18.6%); this reflects the persistence of sex-typed stereotypes for African girls' occupational choices. In contrast, only 6.2% of the sample indicated traditionally male-typed occupations, such as "engineers, surveyors, and architects" (3.9%) or "natural scientists and mathematicians" (2.3%) as their future aspiration.

An examination of the attitudes of rural students versus urban students revealed that there was only one significant difference - that of the mother subscale scores. Rural students expressed more positive perceptions of their mother as a source of support towards them, as learners of mathematics. One can interpret this finding in several ways. It is possible that rural mothers perceive the value of education as higher than that of urban mothers, and thus, are more likely to encourage their daughters to achieve. The fact that their daughters have persisted to the secondary level of formal schooling suggests that there is family support for their continued education. Along this line of reasoning, one

might expect that girls would be more likely to be withdrawn from school in the rural area due to conditions such as: the high demand for their labor contribution, early or forced marriage, lack of family financial resources to support further education, and distance between home and school. These conditions are believed to be more pronounced in the rural area in contrast to that of the urban area; thus, those who do remain in school might have been more strongly encouraged to do so.

As far as can be discerned, differences between educational conditions for rural and urban female students have not been sufficiently studied. In the literature, most discussion is centered on "women's education" without distinguishing between rural and urban students. However, given the contrasting socio-economic environments, one can imagine there would arise differences in the constraints on the education of girls and women.

One of the challenges of administering this particular scale to a sample of Ivorian girls was interpreting the unusually low scores found on both the mother and father subscales. Quite a few students voluntarily responded that they had difficulty responding to these two subscales due to the illiteracy of their parents. Additionally, an assumption underlying the two subscales (referring respectively to the subject's mother and father) is that the biological parents are the central family figures in the daughter's life. In this and other African samples, however, the extended family system is equally if not more important in terms of its impact on the socialization and shaping of African children. In this case, the F-S MAS may pose a problem for this sample in that there is not a subscale that addresses the perceptions of the extended family.

Conclusion and Recommendations

The results of this study show that high-achieving female students (when compared to the low-achieving group) reported less anxious attitudes, more positive attitudes towards problem-solving (effectance motivation), and more positive attitudes towards the usefulness of mathematics. According to the literature, attitudes are important - because they relate to actual achievement

behavior in mathematics, as well as to enrollment in higher-level mathematics courses, and possibly to career interests in science and mathematics (Keys and Ormerod 1977).

Similarly, the findings of the present study support the assertion that several African authors have made regarding the role attitudes play in the STM education of girls and women (Aghenta 1989; Bajah and Bozimo 1989; Osibodu 1989). Unfortunately, many of these assertions lack supporting empirical data. It is suggested that socio-cultural and social-psychological factors contribute significantly to gender disparities in school performance; yet, this is the area of research found to be weakest in Africa. Thus, we can observe that the lack of empirical data and the lack of focus on social and psychological factors necessitate the need for further research.

Educators and parents alike need to become active change agents in fostering positive attitudes in young girls and women in order to enhance their interest and achievement in mathematics. "Because teachers are important role models and career counselors for students, the participation of women in the teaching profession can be a critical factor in challenging existing stereotypes and in promoting and supporting the expanded aspirations of female students" (Adams and Kruppenbach 1986:9). This statement is especially relevant in light of the finding that 85% of the students in this study indicated that they go to their teacher when they encounter difficulties in mathematics. The role of teachers cannot be overemphasized, particularly when "[e]ntry barriers against women serve as obstacles for education. Some of the barriers begin at the primary school level with teachers and textbooks projecting attitudes that discourage school attendance and performance of girls, or promoting stereotypes of girls not being as good as boys in technical subjects or mathematics" (King 1990). The incorporation of curriculum materials (e.g., textbooks) focusing on gender stereotyping, and equity in STM training workshops for teachers is a small but critical step towards sensitizing teachers to these issues and effecting attitude/behavior change.

The role that parents play should not be overlooked. Much of the socialization that shapes a child's life comes from the family, especially from mothers. The fact that rural mothers in this sample were perceived by students as more supportive of mathematics achievement is a revealing finding. Future research and intervention efforts need to uncover innovative and practical means to tap into this unrealized potential of mothers in shaping their daughters' attitudes.

The message of educational equity in STM for girls and women must be promoted in Africa. Presenting short radio or television messages in official and national languages focusing on positive STM attitudes are a tool to reach African girls and their families. Outreach efforts including workshops or conferences targeting girls in school have been extremely effective in the United States and Europe. Similar efforts for Ivorian girls and young women could likewise be planned, with due consideration of the socio-economic environment (e.g., providing scholarships to girls to enhance their attendance). Additionally, the use of theater or dramatic skits holds promise as an effective communication tool within the African environment. Live theater emphasizes many characteristics of traditional West African culture such as oral expression, actor-audience interaction, and the use of folktale or proverbs to convey messages which can be effective in communicating with a village or small community.

Without an aggressive approach toward research and intervention, Ivorian girls and women will continue to "leak out" of the STM pipeline, and will be at increased risk for educational, occupational, and economic disadvantages in the rapidly approaching technologically based future (Bolarin 1987).

Notes

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1. Education at the third level requires, at minimum, the successful completion of education at the second level, or evidence of the attainment of an equivalent level of knowledge at a university (Schmittroth 1991).

2. CM2 is equivalent to the sixth grade in the American educational system.

3. 1^{ere} is equivalent to the twelfth grade in the American educational system.

4. 4^{eme} is equivalent to the ninth grade in the American educational system.

5. A Likert scale is the most popular scaling method used by psychologists and sociologists in both scale development and in final scales. The scale contains a series of 'opinion' statements about a selected issue; the person's attitude is assessed by the extent to which he or she agrees or disagrees with each statement, usually on a 5-point scale. Likert scales are frequently used in psychological research when studying opinions and attitudes.

6. Within the Ivorian educational system, there are two cycles at the secondary level: "premier" and "seconde." The premier cycle corresponds to the classes of 6^{eme}, 5^{eme}, and 4^{eme}. The seconde cycle corresponds to the classes of 3^{eme}, 2^{nde}, 1ere, and Terminale. In the present sample, the division of the age groups into older and younger corresponds closely to the cycles; that is, the group 16 years or younger tended to be clustered in the premier cycle (with the exception of the few cases of students in CM2, the last class of primary school) and the older group largely clustered in the second cycle.

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