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Gender and cultural influences upon career choices in science and mathematics

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Abstract

The purpose of this paper is to synthesize and analyze the research literature related to the relationship of gender and cultural differences and the impact it may have on career choices within the science or mathematics fields. The following questions will be addressed. 1. To what extent, if any, are gender related differences identifiable in the learning of science and/or mathematics objectives? 2. What is the impact of ethnic/cultural differences on science and/or mathematics learning? 3. What is the relationship of gender or cultural differences to career choices in the science and/or mathematics field?

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CHAPTER I

Introduction

"If you can look into the seeds of time and say which grain will grow and which will not... then speak ye to me."

(Macbeth)

Math is the critical filter in the job market, perhaps more so today than ever. Students in today's schools will face a workplace where science and technology are critical components of many different professions, requiring a strong background in mathematics.

In 1970, women earned only 17% of the bachelor's degrees conferred nationwide in science. In 1983, 29% of college seniors graduating with a science major were female. The increase in the proportion of women majoring in life science such as biology or sociology accounts for much of this increase. Their numbers swelled from 23% of total science majors in 1970 to 42% in 1983 (National Science Foundation, 1986). Success in attracting more women into science may occur, but women will not succeed in science (or any other domain) in greater numbers unless girls are

provided with opportunities to develop autonomy (Rosser, 1990).

It has been estimated that, while in school, pupils are classified by sex approximately twenty times a day (Buswell, 1981). Thus children learn the stereotypes of girl and boy, and how each sex is supposed to behave. The particular pathway for development which occurs evolves out of the combination of the individual plus environment (Bateson, 1973).

Given that girls and boys, by the age eleven, differ markedly in their concerns and interests in science, to teach the same science in the same laboratory, and make it interesting to both sexes seems an impossibility (Kelly, 1987). Senk and Usiskin (1983) reported that when comparing test items with students' formal and informal education experiences, findings revealed that when the test items cover material that is taught and learned almost exclusively in the classroom, no pattern of sex differences tends to be found. When experience can be controlled, regardless of the difficulty or complexity of the items, girls and boys perform equally well (Senk & Usiskin, 1983). While there is an increasing body of knowledge about variables associated

with sex-related differences in mathematics (Fox, 1981) little is known about characteristics of classrooms or teachers that contribute to these differences.

In society, differences in the social treatment and teaching of girls and boys and men and women (and of people of different races, classes and sexual preferences) occur. This differential treatment is likely to be the main factor in the differential attraction of these groups to science, although lack of controlled experimental data makes it impossible to rule out psychological or biological differences as possible contributing factors (Rosser, 1990).

> Mathematics educators are learning more and more about school culture, but the culture outside of school has been neglected in our work. We cannot leave the study of culture and society only to anthropologists, sociologists, and a few cognitive psychologists. (Stanic, 1988, p.2)

Further understanding of cultural influences upon education needs to be observed more closely outside of the school setting (Smith & Walker, 1988; Senk & Usiskin, 1983). Culture does not send one set of clear and consistent messages (Stanic, 1988).

Statement of the Problem

The purpose of this paper is to synthesize and analyze the research literature related to the relationship of gender and cultural differences and the impact it may have on career choices within the science or mathematics fields. The following questions will be addressed.

1. To what extent, if any, are gender related differences identifiable in the learning of science and/or mathematics objectives?

2. What is the impact of ethnic/cultural differences on science and/or mathematics learning?

3. What is the relationship of gender or cultural differences to career choices in the science and/or mathematics field?

Significance of the Study

The number of women in science continues to decline regardless of the attempt to provide additional training and in-service to science teachers. The public still views

science as a male dominated field. Until all persons realize that schools alone cannot solve the problem of girls' underachievement in science and technology and that parents, peers and employers all influence children's attitudes relative to their choices, will society begin to encourage and appreciate women in careers most often held by men.

Applicants for almost any employment opportunity will need a good grasp of science, mathematics, and computer technology. The underrepresentation of women in these areas causes concern within the educational realm. This paper examines gender and cultural differences which affect career decisions.

Definition of Terms

For purposes of this paper, the following terms will be defined as:

culture- a body of learned beliefs, traditions, and guides for behavior that are shared among members of any human society (Barrette, 1984)

attitude- a general predispostion or mental set with

regard to any persons, beliefs, or other entities (Hawes & Hawes, 1982)

gender(stereotype)- a rigid image or impression of some category of individuals that is held by a person for all who are believed to be of that group regardless of experience with real people who do not fit the image (Hawes et.al., 1982)

spatial visualization- [the act of] judging the the relationship of shapes and sizes, and particularly of manipulating these mentally to bring about new arrangements of parts to match one of several possible wholes (Hopke, 1968)

achievement- (a) accomplishment of specified objectives, (b) past performance, and (c) what an individual or organization has accomplished in the past, in contrast

with "ability," which refers to what an individual organization can do now (in the present) or in the future (Shafritz, Koeppe, Soper, 1988)

motivation- a psychological term that refers to internal and/or external factors that activate or maintain an individual's behavior (Shafritz, et.al., 1988)

CHAPTER II

Review of Literature

Research on gender and cultural influences on career choices is readily found in educational research. This chapter will examine the effect gender and culture have on career choices within the fields of science and mathematics.

Gender

Previous research has shown that classroom effects on sex-related differences are not easily found or blatantly observed in most classrooms (Fennema & Peterson, 1983).

Fennema and Peterson (1983) completed a study in which the purpose was to identify the teacher-student interaction patterns and student learning activities which were directly related to the development of problem-solving abilities in mathematics by girls and boys. Teacher volunteers were recruited and told the purpose of the study.

In December and January, all students were pretested on the National Assessment of Educational Progress (NAEP) Mathematics Achievement Test by trained testers. Six boys

and six girls who completed the pretest were randomly selected in each class to serve as target students. Each teacher was observed for three separate week-long periods in January through April. In May, all students in the mathematics classes were posttested using the mathematics pretest. Four issues were addressed in this study.

1) Do fourth grade girls and boys differ significantly in mathematics achievement on low level and high level items, and do they differ significantly in their achievement gains over a 6-month period?
2) Do fourth grade boys and girls differ significantly in the percentage of time that they are engaged in various types of activities during mathematics class?
3) Do significant relationships exist between the type of mathematics classroom activity in which girls and boys are engaged and their low level (LL) and high level (HL) achievement, and do these relationships differ significantly for boys and girls?
4) Are there significant sex-related differences in engagement in classroom activities between classes

that show low level and high level mathematics achievement gains that are greater for boys than girls, greater for girls than boys, and do not differ for boys and girls?

Findings revealed that boys and girls did not differ significantly in their mathematics achievement at pretest or posttest time or in their residual gains in mathematic achievement. Boys and girls spent nearly the same percentage of time engaged in each of the classroom activities that were observed. Girls were observed to be engaged in mathematics about 77% of the time, while boys were observed to be engaged in mathematics about 75% of the time.

Both boys and girls scored significantly lower on low level math achievement in mathematics classes in which more time was spent on discussion of social and personal topics. The low level mathematics achievement of boys was significantly negatively related to the amount of time spent engaged in one-to-one interaction with the teacher, the amount of time they spent being helped by the teacher, and the amount of time spent nonengaged in mathematics, in particular in off-task activities.

For girls, one of the most important variables related to their achievement on low level mathematics items appeared to be the extent to which they were engaged in mathematics activities that were cooperative rather than competitive. More specifically, engagement in a mathematics activity in which no helping was occurring and in a activity that was neither competitive nor cooperative were positively related to the high level mathematics achievement of boys and girls. Engagement in a cooperative mathematics activity was positively related to high level achievement for girls, while for boys engagement in a cooperative mathematics activity was negatively related to high level achievement.

The single most important variable related to girls' lowered achievement on low level mathematics (when compared to boys) appeared to be engagement in competitive mathematics activities during math class. Classes where boys gained more than girls on low level mathematics items spent significantly more time engaged in competitive activities than did classes in which boys and girls gained equally. Engagement in mathematics alone did not appear to be a significant variable that accounted for sex-related differences in high level mathematics achievement gains.

The results of this study indicated that student engagement and nonengagement in mathematics activities in the classroom were related importantly to students' mathematics achievement and gender. However, this global variable of student engagement and nonengagement in mathematics does not adequately explain why such sex-related differences in mathematics achievement occurred.

Maccoby and Jacklin (1974) found psychological research on competitiveness had been inconclusive in showing sex differences, but when sex differences were found, research usually showed boys to be more competitive. They also concluded that greater aggressiveness of the male is one of the best established, and most pervasive, of all psychological sex differences. Competition is not perceived to be as much a part of the female sex role as it is of the male sex role (Maccoby & Jacklin, 1974).

The most consistent positive correlations were found for engagement in mathematics activities that were neither competitive nor cooperative. These partial correlations were consistently positive for boys and girls on both low level and high level mathematics problems. Parents must offer their male and female children equal encouragement and

equal opportunities to participate in science and mathematics experiences whether they are cooperative or competitive (Schwartz, 1987).

Another study completed by Weiner and Robinson (1986) found that boys not only have higher mathematical reasoning ability than girls, but also that this ability is the single best predictor of their mathematical achievement. Verbal ability was found to be the best predictor of mathematical achievement for the girls. For both the girls and the boys, neither spatial reasoning ability nor personality factors significantly predicted mathematical achievement.

Due to the voluntary participants of this study, the results will be difficult to generalize to other populations. One hundred and thirty-nine seventh and eighth grade mathematically gifted boys and girls who were attending one of two summers of the Project for the Study of Academic Precocity (PSAP) were the participants for this study.

Resulting from this study, educators need to pay more attention to cognitive processing differences. Females may need to approach learning mathematics differently than males to be successful. Efforts need to be made to foster

intellectual development by effectively utilizing students' strengths, primarily mathematical reasoning for mathematically gifted boys and verbal reasoning ability for mathematically gifted girls (Weiner & Robinson, 1986).

Roxanne Cramer completed a qualitative study in 1989 in which she interviewed four, gifted nine year old children-two boys and two girls. Her concern in their attitudes toward mathematics and female involvement in mathematics was the driving force of her study. These four students attended a gifted center full-time in an affluent Washington D.C. suburb. These students were paired boy with boy and girl with girl. These two groups did not meet together nor did they know what the other pair discussed. She found the same reasons explaining the male/female disparity-conflicting expectations, lack of confidence, lack of female role models, and especially sex role stereotyping. Differences were noted between the girls' and boys' reasons for why they think they are good in mathematics. The boys attribute their expertise to hard work and ability, where as the girls see their competence as being determined by someone else. Other findings of this study were all four believe mathematics is important with the boys believing

mathematics is the most important subject of all. One of the boys explained that boys enjoy risky activities and that alone had something to do with their willingness to take risks in their school work. Cindy, one of the girls pointed out that boys are very self-confident and this may be why they ask questions more often. Both girls believed that girls become more nervous, and that self-confidence plays a large part in boys' ability in math. Cindy asserted that they get this self-confidence from other boys. Doug believes that boys and girls look at things in different ways. Jeff suggested the possibility that boys are better in math than girls because girls "think" boys are better. Doug offered the ultimate reason: "Maybe boys are just built to be good at math and girls are built to be good at housekeeping."

Stereotypical thinking dominated the boys' responses to nearly every question. Their explanations for women's lower achievement centered on females' inadequacies. They felt that girls lacked physical strength, lacked mathematical knowledge, and even lacked ability. They did not once consider the possibility that sexism or lack of opportunity may have been responsible for underachievement by females.

The females, on the other hand, believed that females are smarter than males. Their explanations included several somewhat stereotypical female characteristics, such as girls' nervousness and lack of confidence. Not having as much physical strength as boys also seemed to be an important factor. The girls were considerably more aware of past and present sexism and its effects on women's achievement than were the boys, who never mentioned it.

The longterm effect of these attitudes on girls may account in part for their loss of interest in pursuing advanced math courses, leading to inadequate preparation at the college level and subsequent underrepresentation in many professional fields.

Culture

Schooling is an instrument for the 'enculturation' of youth. When cultures of the school or the teacher are not consistent with cultural values of students, there is danger of cultural conflicts. In such a situation, teaching may become a process in which the teacher imposes his or her own values and beliefs on students, and the students resist learning that is imposed upon them. Thus, an important task in school involves how to maintain the continuity of students' cultural backgrounds, at the same time prepare students for a wider society. A serious concern in the current state of teaching, however, is that teachers often do not consider cultural differences as an important issue in the classroom. To better understand learning characteristics of students, teacher education programs should consider various cultural components in educational settings. The programs should help prospective teachers be aware of the cultural diversity of students. The programs should provide prospective teachers with tools and practices to deal with students from different cultural backgrounds.

(Contreras & Lee, 1990, p. 442)

Cazden and Erickson (cited in Contreras & Lee, 1990) stated that a cultural perspective may explain differential treatment in terms of cultural differences between the school or the teacher and students from different ethnic backgrounds. According to this perspective, differential treatment occurs when cultural values of the school or the teacher (usually the mainstream culture) are inconsistent or even in conflict with cultural backgrounds of students (usually ethnic minority groups). Thus, cultural congruence or incongruence influences the degree of students' access to school knowledge and skill.

Conducting a study over the period of one school year, 1985-1986, Contreras and Lee included four classes taught by two science teachers. Each of the teachers taught one enriched and one regular class. The regular classes involved in the study were not typical regular classes, but "problem" classes as defined by each teacher as his or her worst in terms of academic ability, behavior conduct, and family background. A medium sized urban middle school located in a middle class midwest neighborhood served as the research site. Students were sixth through eighth graders

representing a range of ethnic and socioeconomic backgrounds.

Each of the four classes was observed by two observers at least twice a week. Data for each teacher were analyzed to yield major patterns of differential treatment between the enriched and regular classes. Significant differences were noted in the treatment of the first two classes. He spent more time on instructional activities, presented more content knowledge, provided more support for students' lab work on his initiative or by students' requests, and tried to motivate students for science learning with his enriched class. Personal contacts between the teacher and students were close and cordial. In the regular class, content teaching was not his primary concern (usually he was concerned about managing students' behavior). He did not provide information and seemed to avoid teaching altogether. He kept his distance.

The second teacher in the study, spent equal amounts of instructional time in both classes. Content of instruction and teaching strategies were similar among both groups. Teacher/student interaction was positive and supportive.

Due to the first teacher's actions in the regular class, school policies and classroom practices seemed to exacerbate the "cultural gap" that already existed between the teacher and students and among students of different cultural and ethnic backgrounds.

At the Center for Research on Elementary and Middle Schools Entwisle & Alexander (1989) were involved in a study of Beginning School Math Competence: Minority and Majority Comparisons. The participants were from a large random sample of urban children, particularly blacks and whites. The variables considered for this study were (a) race, (b) sex, (c) prekindergarten experience, (d) Kindergarten experience, (e) meal subsidy, (f) parent's ability estimate, (g) parent's expectations, (h) parent's educational attainment, (i) California Achievement Test scores, and (j) family type. Results indicate when children are grouped by parent's educational level, the black-white differences in computation scores are small and inconsistent except for children whose parents have some post-secondary education. In families where parents are high school dropouts, scores for blacks and whites are seven points apart, with blacks exceeding whites. For children whose parents have some

post-secondary education, though, where white parents have almost two more years of education than do black parents, whites' scores exceed blacks' by a substantial margin (23 points). For math concepts (reasoning) the picture is much the same. Again, though, race differences for children whose parents have some post-secondary education are pronounced, and favor whites by twenty-nine points. Another indicator of possible socioeconomic disparity between minority and majority children is that when the parent has some post-secondary education, 49% of the black children as compared to only 8% of the white children received some meal subsidy. Beyond this, differences by family type complicate the picture because about 73% of white children come from mother-father households compared to 47% of black children. Verbal test scores are very close, prekindergarten and kindergarten attendance is virtually identical, and parent's expectation for the child's first mark in math is close to a B (2.8 for blacks and whites). The parent's level of material resources and family configuration tend to favor whites but variables classified as psychological resources of the two groups look fairly comparable. This study mainly focuses on the variable of race. Whatever the long term

relationship has been between human biology and human culture, researchers may need to think of culture as an independent variable because it is one which can be controlled (Stanic, 1988).

Career Choices

In the last decade, a central concern of researchers and educators has been the underrepresentation of women in the mathematics-related careers in our society. Lucy Sells (as cited in Becker & Jacobs, 1983) examined the mathematics backgrounds of first year students at the University of California-Berkley, and found that 57% of the men but only 8% of the women had sufficient high school mathematics to take college calculus. Sells identified mathematics as the critical filter that keeps women out of many careers.

Despite recent gains, women remain substantially underrepresented in science at the college level. Their numbers are lowest in engineering, where only 13% of the degrees awarded in 1983 went to women. In the same year, women earned 28% of the degrees in the physical sciences, and 39% of those conferred in computer science and mathematics (National Science Foundation, 1986).

Responses to NAEP items indicate that lack of expertise in science leads to lack of understanding of science and contributes to negative attitudes toward science. Responding to questions concerning science as a career choice, 13- and 17-year old girls felt that working in science would not "be fun," would be "too much work," and would not be an endeavor they "could do" well. Females of both age groups had lower aspirations in science-related fields than did males. In addition, fewer girls than boys wanted to "work with scientists to solve problems," "make field studies," or "read science articles." They were less interested in learning about science careers and were nearly 15% below the national mean in wanting to "design and build things." Girls also felt less confident that there were science jobs they could learn to do (Kahle & Lakes,1983).

Using a nationally representative sample of students, Ware & Lee (1988), examined the personal, school and attitudinal factors which differentially affect the choice of a college science major for men and women. The study sample was drawn from High School and Beyond (HS&B), a national, longitudinal study of the goals, attitudes, experiences, and achievement patterns of students who were

high school sophomores or seniors in 1980. The original sample consisted of 1,000 schools and 58,000 students. Base year data were collected in 1980 and the first follow-up was in 1982. The sample was selected from the HS&B 1980 seniors who were enrolled in a 2- or 4-year college in 1982 and who had reported a declared or intended college major on the 1982 questionnaire. Data were analyzed separately for men and women. In 1982, when college sophomores were asked to state their declared or probable majors, 39.8% of the men and 14.3% of the women in the sample named a scientific field. In addition, results of the study show that male science majors scored higher on a high school measure of mathematics achievement and exhibited more positive attitudes toward mathematics than their female peers.

Science majors of both sexes scored higher than students in nonscience fields. Women who were attending a 4-year college, who reported having been influenced by high school teachers and guidance counselors in making plans for college, and who placed a high priority on future family and personal life were less likely than their female peers to choose a major in science. Females who reported a positive attitude toward mathematics in high school were more likely

than other women to major in a scientific field in college, as were those who took more mathematics courses at the secondary level.

Male students who were attending 4-year colleges who offered positive assessments of their high schools, and who came from families of relatively high socioeconomic status were more likely to major in science than other men. As high school students, male science majors were more likely to enroll in science (but not mathematics) courses and to be involved in extracurricular activities than their male peers who chose majors in nonscientific areas.

The choice of a science major was predicted by high educational aspirations, high grade point average at the secondary level, and a preference for science and mathematics courses over English and social studies courses in college for both men and women. A precollege orientation toward science and mathematics may be a prerequisite for future specialization in a scientific discipline. For women, educational aspirations are a stronger predictor of mathematics enrollment than science enrollment in college, whereas for men, the reverse is true.

The results of this study provide additional evidence of women's continuing underrepresentation in science at the college level. The indication that high school teachers and guidance counselors can in fact make a difference in their female students' persistence in science and mathematics is one of the most important findings of this study. It is essential that career awareness develop an across the board spectrum of careers and that it not be focused on the college graduate (Pederson & Bleyer & Elmore, 1985).

CHAPTER III

Conclusions

The major purpose of this paper was to review the available literature in an attempt to answer questions concerning gender and cultural impact on career choices in the science or mathematics fields. This review of literature intended to answer three questions. First, to what extent are gender related differences identifiable in the learning of science/math objectives? Classroom effects on sex-related differences are not easily found or blatantly observed in most classrooms. Results suggest, in fact, that activities in classrooms may have different influences on girls' and boys' learning of mathematics. Conclusions showed that student engagement and nonengagement in mathematics activities in the classroom are related importantly to students' mathematics achievement. This global variable of student engagement/nonengagement in mathematics does not adequately explain sex-related differences in mathematics achievement.

The second question intended to have been answered is what is the impact of ethnic/culture differences on science

and/or mathematics learning? Research on cultural differences in classroom settings show that problems of miscommunication and misunderstanding arise when cultural differences appear in the interaction between teacher and student. Differential treatment continues to occur in the classroom where cultural values of the school and the teacher differ from that of the student. As a result, this influences these "minorities" into choosing careers in fields other than science or mathematics.

> Furthermore, whether the culture inside or outside schools is being studied, the critical sociologists remind us that people are not passive recipients of cultural messages. Instead, people accept some messages, mediate others, and struggle with and resist still others. It is also true that cultural messages conflict with each other. There may be a dominant culture, but culture is not uniform and cultural messages are not all consistent. (Stanic, 1988, p.10)

Finally, what is the relationship of gender or cultural differences to career choices in the science or mathematics field? The review of the literature revealed a relationship

exists between gender and cultural characteristics impacting career choices for men and women. Rekdal (cited in Cramer, 1989) stated that women have been and will continue to be restricted educationally and their career options radically circumscribed by inadequate math backgrounds. Mathematics is a major key necessary in unlocking a majority of important career opportunities available for our most intelligent and academically able students.

There is a need for further research in the area of cultural influences upon females. Questions to be answered, are to what extent do these influences impact 1) their science and mathematics achievement and 2) their choices of careers in one of these fields? A majority of the research identifies culture as being from a particular race or ethnic background. Culture should include characteristics such as socioeconomic background, parental attitudes, values, and experiences. Little research has been done on the impact these characteristics have upon achievement. Future research focusing on these characteristics would provide us with greater insight into why women today show little interest in pursuing a degree in science or mathematics.

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