How do we interest and retain more women in the field of mathematics?

"Women now make up nearly half the undergraduate math majors in the U.S. (1993 Annual Survey of the American Mathematical Society and the Mathematical association of America); yet in graduate math programs, only about one-quarter of the American students are women" (Adhikari & Nolan, 1997, p. 17). For women who choose SME (Science, Mathematics, Engineering) majors, persistence rates in the major are significantly lower than that of male peers. (Seymour, 1995, p. 438) I am interested in the topic because I am a female who experienced pursuing undergraduate and graduate mathematics degrees. I want to know what I can do to help motivate other women in mathematics. While reading the literature, I became aware of subtle personal experiences that paralleled common experiences of women pursuing mathematics majors. Whereas I had informally considered my attempts at fair, consistent treatment for all students to be positively related to motivating women (and other minorities) in mathematics, upon reading the literature a strong case is made for additional support to different groups.

Although I will focus the majority of the paper on college experiences that influence women in SME majors, literature also points to the influence of pre-college coursework. “Maple and Stage (1991) found that students who took more science and math courses in high school were significantly more likely to choose science and math majors in college” (Trusty, 2002). Farmer, Wardrop, Anderson, and Risinger (1995) found taking elective science courses in high school had a moderate direct effect on
persistence for women in science-related careers, but taking elective math courses did not. (p. 163) Although in this research taking elective math courses was not found to effect persistence of women in science-related careers, I contend that math courses are still critical as they are prerequisites for science electives of chemistry and physics. The National Science Foundation has reported, “young women have lower interest in math courses and take fewer advanced math courses” (Farmer, Wardrop, Anderson and Risinger, 1995, p. 157). In addition, Seymour and Hewitt (1997) found the effects of inadequate high school preparation to be the most common contributor to early decisions to switch from SME (science, mathematics, engineering) majors to non-SME majors (p. 79). Seymour (1995) also points out that studies have noted “the subtle deterrents to active participation in mathematics and science which bear upon precollege girls” (p. 438) and potentially inhibit the development of interest and career aspirations in SME fields. In consequence, I contend that teachers and high school counselors play critical roles in encouraging young women to take more science and mathematics courses in high school.

Elaine Seymour and Nancy M. Hewitt did extensive research exploring the range of factors contributing to choice of a SME major and attrition among SME majors in college. They used Cooperative Institutional Research Program (C.I.R.P.) survey data to construct patterns that distinguished the population of switchers from non-switchers; they also looked more closely at gender and race/ethnicity differences. In conjunction with the tabulated survey data, Seymour and Hewitt acquired extensive qualitative data from personal interviews and focus groups.
The most commonly cited factor for choosing an SME major by 18% of all informants was the active influence of people significant to the student. Moreover, "women were about twice as likely as men to have chosen an S.M.E. major through the active influence of someone significant to them" (Seymour & Hewitt, 1997, p. 77) such as teachers, family and counselors. On the other hand, women “found it much easier than did young men to get parental and peer support for their desire to move into a non-S.M.E. major” (Seymour, 1995, p. 446). “Men felt more tied to their original choice of major and/or career as a matter of duty to parents, personal responsibility and fulfillment of future family obligations” (Seymour & Hewitt, 1997, p. 277). In contrast, women were often more "altruistic than men in their career goals” (Seymour & Hewitt, 1997, p. 237). Therefore, whereas significant people may influence more women than men in choosing an SME major, also parental support may allow women to switch from an SME major more easily than men.

Through ethnographic inquiry, Seymour and Hewitt studied "the connections between high demonstrated ability among a consistently smaller number of women entering SME disciplines, a tendency to lose confidence after entry, and a vulnerability to switching which exceeds that of the male majority" (Seymour & Hewitt, 1995, p. 440). Similarly, Adhikari, Nolan and others noted female mathematics majors, in contrast to males, show less self-confidence in their abilities, place greater importance on the support of teachers and friends, take fewer honors classes, and are less enthusiastic about college math in comparison to high school math. (Adhikari & Nolan, 1997, p. 17)

Seymour and Hewitt state, "When women first enter SME classes, they encounter two kinds of experiences, both of which are new and uncomfortable." (Seymour and
Hewitt, 1995, p. 458) The first is the weed-out system which women share with their male peers; however, women do not assign the same meaning to the system as men do. The second new experience arises as a consequence of entering a traditionally all-male social system. Competition has traditionally been a technique used to motivate young men to work hard in a variety of areas such as medicine, law, military training and sports. On the other hand, social systems result in women being motivated by the desire to receive praise rather than the desire to win. Young women who performed well in high school and arrived at college with the height of self-confidence may begin to feel isolated and insecure as a result of the weeding-out system and the harshness of the teaching methods. In addition, Seymour and Hewitt suggest the deliberate denial of nurturing during the first two weed-out years further disadvantages women who respond more to praise. Often faculty begin mentoring students in their junior year; this may be too late for women.

Very few women interviewed in the Seymour and Hewitt study indicated blatant unacceptable behavior by SME faculty or peers. However, subtle common experiences emerged in the data. "Some faculty were seen as covertly attempting to drive women from the major by making them feel uncomfortable and unwelcome; others were seen as ignorant of how to behave toward women in an academic or collegial context" (Seymour, 1995, p. 452). In addition, some male peers did not want to share the elite intellectual status often attributed to SME students. As a result, if women did well, there was a widespread belief that some female students used their feminine wiles to gain an unfair advantage. Deborah Haimo deduced, "The overt, flagrant actions of the past are now covert, very subtle, and much harder to overcome." (Haimo, 1994, p. 8)
Women "who have already accepted competition as a way of relating to others in high school, or in sports and games" (Seymour and Hewitt, 1995, p. 462) will be better able to adjust to the current system. In addition, "women who persist, enter with sufficient independence…to survive denial of faculty support or performance interpretation, and refusal of male peer acceptance" (Seymour & Hewitt, 1997, p. 274).

Although not a factor in switching in undergraduate mathematics, senior women expressed concerns about difficulties in managing SME careers and/or graduate school alongside marrying and raising a family. In fact, "some male faculty had begun to offer warnings to their female students about the limitations on both career and on family life which they thought were brought about by attempting to" (Seymour & Hewitt, 1997, p. 291) undertake both simultaneously. Hence, although not a factor in switching during undergraduate mathematics, it may be a factor for proportionally fewer women pursuing graduate degrees.

Seymour and Hewitt also suggest that “being taught by women faculty was important in helping undergraduate women feel more confident that they belonged in their major and that they could succeed” (Seymour & Hewitt, 1997, p. 303). Again, this may be a factor in fewer women going on to pursue mathematics graduate degrees.

What can we do to support women in mathematics majors? In the long term, Seymour and Hewitt suggest moving pedagogy from a focus on teaching to a focus on learning via using more cooperative, interactive and experiential learning contexts. Also, they suggest changing from selecting for talent to nurturing talent. These actions "will dis-proportionately increase the persistence rate of able women in S.M.E. majors. It also promises to reduce the loss of able male students." (Seymour & Hewitt, 1997, p. 314)
To help women succeed in the current structure of mathematics education, researchers are suggesting that we provide women with extra support. (Haimo, 1994, p. 8) In Deborah Nolan’s conference report on models focused on increasing representation of women in mathematics PhD programs, several common themes arose. (Nolan, 1997) Many course designs and models incorporated group work and discovery learning. Many programs paired student participants with faculty mentors (men or women) to work on portions of the faculty’s research. Margaret Robinson at Mount Holyoke College stated, “We believe that to build confidence, self-esteem, and mathematical maturity it is extremely important for our students to experience mathematics as a creative process.” (Robinson, 1997, p. 113) Some programs specifically tried to involve women faculty and graduate students as mentors to women who might potentially pursue graduate math degrees. Overall, the programs were not remedial; instead, they were challenging and engaging.

These models have several common characteristics with the Treisman model for minorities (including women) at Berkeley (Malcom & Treisman, 1987). In addition, the models have characteristics that counter common perceptions by switchers of SME programs as communicated in the Lipson Study (Tobias, 1990, pgs 74-79) and Seymour and Hewitt’s research (Seymour & Hewitt, 1997). Important elements are advising/mentoring, cooperative learning, promoting study relationships, and discovering the creativity of research. Also note, the programs are not intended to be remedial. Instead, the programs intend to challenge students to interact with the material and to understand the material.
I do not believe that mathematical understanding is different between females and males. However, it appears that for many men and women, interactions with the material, people and learning environments affect mathematical confidence. First I suggest that if early learning environments helped all students build better control and beliefs in mathematics, maybe women’s confidence levels could stay in tact in college if competition, lack of mentoring and lack of community existed. It does appear that special effort should be made to mentor and advise women in mathematical programs throughout their college experience. Special effort should be made to help women find study relationships, particularly at universities with a strong majority of male mathematics students. More opportunities should exist in mathematical courses for cooperative and discovery learning. Research experiences should be provided for senior undergraduate women and master’s program women. Perhaps mentoring/advising could include discussions of part-time career opportunities that could work well with family responsibilities.

Although I am not currently involved with upper division undergraduate mathematics majors, based on this research I intend to adjust my teaching strategies. Through these changes, I hope I can better teach women, minorities and students who have not had previous positive mathematics experiences. Although I will continue to use lecture during many of my classes, I will look for more cooperative and discovery activities. I will strive to find more opportunities to talk with individual students and to personally provide praise and advise. I will try to think of ways to promote positive study relationships. I will try to model control and I will try to challenge beliefs that all
problem solving should be done quickly and that there is only one way to do a problem correctly.

I will end with some of my personal experiences. At the beginning of the paper, I thought proportionately fewer women pursued mathematics degrees. I found out that about the same proportion of women as men pursue undergraduate mathematics, but that proportionately fewer women attain graduate mathematics degrees. As I began, I also thought I had had success in undergraduate and graduate mathematics and was curious how my experiences compared with other women. Near the end of my literature review it dawned on me that although I had attained a masters in mathematics, I had not attained a PhD in math. I may not have been completely successful after all.

When I went to high school, we had no career/educational counselors. I would not consider my math teachers as impressive. But, I look back and realize I did have some experiences that paved the way for my mathematics degree. My Algebra II class (junior year) was very small and the teacher basically had us learn the material ourselves. We could work together if we wanted. From this class, I think I developed skills in assimilating and accommodating the material from reading the text and struggling with the concepts on my own or with other students. Perhaps, some issues of control were strengthened in this course. My teacher in Geometry (sophomore year) and Mathematical Analysis (senior year) was very introverted and not dynamic; however, his curriculum was challenging. I was not allowed to develop a belief system in these courses that solvable problems could be worked in five minutes if you knew the material.

I would not consider any of my mathematics teachers as mentors. However, I did have a high school physics teacher that influenced me. He chose me for an Engineer for
the Day experience. Frankly, the experience resulted in my decision not to go for an engineering degree. I went to a Petroleum plant, but the ‘mentor’ engineers forgot I was coming that day. In the morning, they sat me in a room by myself to look at engineering manuals (which made no sense). They did take me for a nice lunch and gave me a short tour of a smelly, cold facility. Obviously, I did not like the experience. But, I think having been chosen bolstered my confidence as a science/mathematics student.

I began college with no clear career goals. Using Tobias’s classification, I may have been a borderline first tier/second tier student. I had done well in most subjects in high school, but had taken more science and mathematics courses than humanities. However, I did not have a set science/math career goal. In college, I started as a business major, then thought about computer science. I finally took a career inventory test my sophomore year. At that time in my life, I was very focused on wanting to choose a field that was service related. The teaching career came up throughout the results. I seriously considered special education teaching. A female advisor pointed out I had to get an undergraduate teaching degree first before going on with the masters in special education. She suggested I do secondary mathematics because I did well in math and we needed more female mathematics teachers (she taught in women’s studies). I look back and am surprised by the influence of this counselor; as a result of this course of events I became a mathematics major.

I think several factors were involved in my success in undergraduate mathematics. I think my challenging high school curriculum was a foundation for this degree program. I was rather competitive by nature and had a healthy level of self-confidence. I also had good coping skills. For instance, I started Calculus III with an awful teacher. He would
walk into class, open his book to the section (I’m pretty certain he did no preparation) and do an example clearly written in the section. I could already read the book; I wanted more. After a few of his classes, I asked the Honors Calculus III teacher if I could join her class. I had taken her for Honors Calculus I, but had missed out on the sequenced Honors Calc II while I was searching for a major and had instead taken regular Calc II in the summer. She allowed me to join. Note, other students remained in the poor teacher’s class (perhaps they were the first tier students who would put up with anything). I also managed to take classes where teachers did not give horrendous tests and grade on a terrible curve. I think I would have had a strong tendency to leave the major if I had received 50% on tests even if they had curved to grades of A or B. In other words, my confidence was not eroded in the courses I took; however, I think my confidence could have been eroded in a different environment.

Several factors resulted in my decision to get a master’s in mathematics. Once in mathematics courses, I found I really enjoyed the material. Special education went out the door. However, when I had my first teaching experience as a long-term substitute, I crashed and burned. The seventh and eighth graders were such an emotional challenge that I questioned if I had pursued the right degree. After some time, I decided to go back for my master’s in mathematics with my goal to teach at WSU when I was done (although I was aware it would only be for a six year non-tenure track position). I had taught as a lecturer during the last semester of my bachelor’s degree and had really enjoyed teaching algebra at college. I had also taken some of my final courses as graduate credit under the senior rule because I had had less than 9 hours left; this resulted in increased confidence.
Overall, faculty were supportive, yet I had some inkling that they were recruiting any possible person who could handle the coursework. I did have some similar experiences to those described by Seymour and Hewitt. During my first graduate year, I had a couple of peer male office mates who suggested that I had done well in a course because the teacher liked females. Thank goodness, I soon found a peer (turns out male) who I could work well with. We had a comparable skill level, similar values and many of the same classes. Although we did most of our homework on our own, we could discuss topics and ask each other for help if we were really stumped. Had I been isolated, I do not know if I would have as much success in my master’s program. Also, I think I was attracted to the statistics track because I had the opportunity in some courses to interact more with the material. Although the majority of the statistics courses were still taught through the lecture style, some experiences with projects and group work existed. Although I was confident in these courses, I did not have experiences that exposed me to research in mathematics. I had no confidence that I could ever do research in math.

After six years of teaching at WSU, I had to find another job. I was lucky enough to find a small university with an emergency opening (such that they were willing to take a master’s degree applicant). However, there was underlying pressure to pursue a PhD. I began one doctoral course in theoretical statistics, but soon dropped the course. By this time in my life, I was married with four children and teaching full time. I certainly did not feel that I could compete with students who could devote much more time than I could. I was isolated; I was no longer in an office with other graduate students. Finally, I must admit - I really do not know if I had the ability. Although I believe the majority of people can develop the mathematical understanding for high school algebra, I do not
believe that everyone can develop the understanding to earn a PhD in mathematics. I
certainly did not have enough interest in the abstract level of the material. Would less
isolation have helped? Would more cooperative, discovery learning have helped?
Would more time to focus on the material have helped? Would more confidence in the
ability to do mathematics research have helped? Or was it mainly a lack of talent?

Probably, some combination resulted in a mathematics PhD casualty.
References


