High-Achieving Young Women's Perceptions of Mathematics in College

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Abstract: The high achieving young women in this investigation are not choosing to study mathematics at the college level, despite being in advanced and college level mathematics courses throughout their high school careers. This study looks at their perceptions of mathematics and role it plays in their educational and career decision making processes. The interviews were coded using six different themes of mathematics as a tool. Each of the themes are supported from quotes from the participants. The results of this study may provide additional insights as to why young women are not pursuing advanced mathematics at graduate levels.

Introduction and Background

In light of recent efforts by the National Science Foundation and several university mathematics departments to increase the number of women pursuing mathematics graduate degrees, this study explores possible reasons that high-achieving young women are not pursuing advanced mathematics degrees by looking at their perceptions of mathematics, and the role they perceive mathematics plays in their education and future careers (Golde & Walker, 2006; Herzig, 2002). The findings presented in this study are limited to the young women who participated in a ten year longitudinal study and examine some possible explanations for why women are not choosing mathematics as a career or as a field of interest for study in college and into graduate school. The longitudinal study began in 1999 and is still currently ongoing. The original goal of the study was to increase middle school girls' interests in math-related careers through mathematical explorations of urban problems within their communities (Berenson et al., 1999). Each summer a group of middle school girls attended a math and science day camp. The first three camps were for girls who were taking Algebra I in middle school. Later, the camp was opened to all girls interested in attending.

The young women participating in this research were identified previously, during middle school, as high achievers (Berenson et al., 2004). Each of these young women took Algebra I in the middle school and participated in a math and science summer camp for girls during middle school sponsored by the longitudinal study. These young women are contemplating careers in science, technology, engineering or mathematics (STEM) or STEM related fields. For this study a STEM related field, is one in which there is a heavy emphasis of science, technology, engineering, or mathematics. One of the young women who is interested in medicine and is majoring in neuroscience represents an example of a STEM related field. The researchers considered this a STEM related field. It is interesting to note that none of the young women in this study are considering a career or major in mathematics. This is surprising because most of them took college mathematics courses for college credit while attending high school.

Participants

The analysis for this study consisted of examining 12 college interviews. These interviews were conducted during December 2006 and January 2007. The young women were college freshman, sophomores, and juniors. To date, a few of these young women have graduated from college and others are in their final years. Table 1 outlines the participants, their grade at the time of the interviews, what type of university they attended, and what their career interests were at the time of the interview. All of these girls were high achieving, as defined by the study (Berenson et al., 1999). High achieving in this papers means that the girls selected to take Algebra I during middle school, therefore placing them on track to complete calculus prior to graduating from high school. The girls continued their high achieving status throughout high school. Ten of the young women took Advanced Placement (AP) Calculus and/or AP Statistics. Also, at least nine of the young women took at least one AP science course. All except one of

the young women attended universities of their choice. The one exception has split her time between community college and a large state university. She felt that this was a better fit for her academic goals.

Table 1
Description of the Participants

Pseudonym	**Year in College at time of Interview**	**Career Interest and/or Major**	**University**
Cara	Freshman	Nursing	Community College, Large Public University
Yasmin	Sophomore	Anthropology, War & Defense, Medical School	Large Public University
Wendy	Sophomore	Accounting	Small urban college, Large Public University
Zena	Sophomore	Biology/Pre-Med	Small Private University
Julie	Freshman	Biology, Medicine	Large Public University
Kay	Junior	Accounting	Large Private University
Meg	Junior	Economics	Small Private University
Maureen	Freshman	Spanish, Foreign Studies, International Relations	Large Public University
Shelly	Junior	Neuroscience	Small Private University
Carol	Sophomore	Physical Therapy	Large Public University
Ray	Freshman	Business/Italian	Large Public University
Katya	Sophomore	Business/Spanish	Large Public University

Methodology

This study explores high achieving young women's perceptions of mathematics during the young women's undergraduate years. Twelve college interviews were conducted in late 2006 and early 2007. All interviews conducted were semi-structured and conducted in person. During the semi-structured interviews, a series of structured questions were asked in each interview with researchers also using open-ended questions to probe more deeply (Gall, Gall, & Borg, 2003). These interviews focused on the young women's decision making processes concerning career choice, and the role of science and mathematics in those decisions. All interviews were audio-taped and field notes were taken by the interviewers. Interviews lasted

from 60 to 90 minutes. The research question for these twelve interviews was 'What are high-achieving women undergraduates' perceptions of mathematics?'

The themes for the young women's perceptions of mathematics emerged as a result of coding the interviews using the Community of Practice framework (Wenger, 1998). The mathematical perception themes are based on grounded theory (Glaser, 1998). The themes for mathematics perceptions were expanded and defined during team meetings at a later date. The interviews were then examined and coded again using the mathematical perceptions themes. During the second level of coding the themes were further developed and the definitions rewritten using the young women's perceptions of mathematics. As a result, it is important to remember that the codes are based on the participants' definitions of what they think mathematics is.

There were six themes developed through the coding of the interviews. These themes are not mutually exclusive; therefore, some of the young women's quotes about their perceptions may fit into more than one of the codes. Each of the codes is important for interpreting how the young women view mathematics and its perceived role in their futures and career choices. The six codes are: (1) Mathematics as a tool for thinking and problem solving, (2) Mathematics as a n educational tool, (3) Mathematics as a tool for career pursuit (4) Mathematics as a tool to build confidence in abilities, enjoyment, and satisfaction, (5) Mathematics as a tool for connecting to realistic contexts (6) Mathematics as a tool for teacher influence on the young women's perceptions of mathematics. Each code is explained in Table 2.

Table 2
Description of Codes

Codes	Explanation
Mathematics as a tool for thinking and problem solving	Young women like to be challenged, math increases their thinking skills, also some talked about the problem solving skills they developed in higher mathematics courses
Mathematics as an educational tool	Advance study in other areas such as Chemistry or Physics, business degrees, as well as in future mathematics classes.
Mathematics as a tool for career pursuit	Mathematics will help them in their pursuit of STEM related careers as well as other types of careers.
Mathematics as a tool to build confidence in abilities, enjoyment, and satisfaction	The young women are good at mathematics, and therefore, it helps them build confidence in their academic abilities. They also express that they have natural ability and genuinely enjoy mathematics.
Mathematics as a tool for connecting to realistic contexts	The young women talk about liking classes that are connected to other areas. Prefer applied mathematics classes that are relevant for their majors and career interests.
Mathematics as tool for teacher influence on the young women's perceptions of mathematics	The young women describe classroom experiences and teachers in which their perceptions of mathematics was changed. Including their enjoyment and satisfaction in studying mathematics.

Discussion of Findings

In this section, the six themes will be discussed using quotes from the interviews to illustrate each of the codes.

Mathematics as a Tool for Thinking and Problem Solving

Four of the twelve young women expressed the notion that their study of mathematics had enhanced their ability to think, analyze problems, improve their problem solving skills, and help them think abstractly about ideas. They discuss this view from a variety of perspectives including; how they think it will relate to their careers and how they perceive their skills with

relation to their course work. For example, Meg's description stems from how she sees mathematics relating to her ability to problem solve:

> *I think a lot of it is just being able to problem solve correctly. How to read a problem and think through the kind of steps that you would need to take and solve. So, I think a lot of the math classes we're taking helped to develop my analytical and quantitative and critical thinking skills*

Mathematics as an Education Tool

The young women believe that mathematics advances their study in other areas, such as Chemistry, Physics, or business courses. Ten of the young women's interviews contained this code. They also believe that it helps them in future mathematics courses. Often the young women take mathematics courses because they are required in high school, or because their college majors require mathematics. However, at the college level, the young women may get to choose which mathematics courses they take. For example, Zena discusses her choices for mathematics courses:

> *For our general college requirement, we have to take two courses that are quantitative studies …and most of those are math courses or Econ or computer science. I took Multivariable calculus for one and I want to take statistics for Bio-majors because I think I want to be a bio major, and that's the most relevant thing...*

They also expressed that mathematics can contribute to their continued academic success. Ray, a Business and Italian major, stated that her statistics and mathematics courses help her in preparing for her college education:

> *Well, I realized that a lot of business has to do with financing and stuff like that. So, a lot of statistics and math goes into that, and accounting, if I want to do anything like that. And later on, if I want to pursue getting an MBA, a lot of math is tied into that.*

Mathematics as a Tool for Career Pursuit

Nine of the young women spoke to the usefulness of mathematics to their chosen careers, most of these were among the older college students. This may be a result of the fact that the younger students are still exploring their career options and are not settled on their goals and college majors. As the young women entered their later college years those career goals became more focused, they selected majors and chose internships and activities that directly related to their career choices. However, there was still a great deal of decision making concerning careers. Yasmin (Pre-Med. major) stated, … *that math is an integral part of medicine and why you get a certain dose that you get or why, I don't know, why medicines are the way they are*. However, she did not know how to relate specific higher level classes such as Differential Equations to medicine. Julie, a college freshman, was much more general in her description of how mathematics and science will help in her career choice: *I was always told that if you want to be a doctor, you need to be good at math and science.*

Mathematics as a Tool to Build Confidence in Abilities, Enjoyment, and Satisfaction

All of the young women expressed ideas related to the notion that mathematics can build one's confidence and provide satisfaction. These young women were high achievers in their high school mathematics courses, adding to their self confidence. The young women were good at math and felt that they had some natural ability which enabled them to excel. Shelly stated, "Math and science always came easily to me." However, excelling at mathematics did not only build confidence in math but in other subjects as well. Katya felt that *taking the math that I have, I feel comfortable in many of the required math courses… But, I definitely realize the benefits of having those math courses… I don't feel as scared as I feel some of my peers are.*

Mathematics as a Tool for Connecting to Realistic Contexts

Eight of the college interviews revealed how the young women viewed mathematics connections to realistic contexts and should not be learned in isolation. That the young women chose to take math-based courses related to their fields of interest or preferred to take statistics courses over other types of classes supports this view of the role of mathematics in their lives. They seemed to believe that these courses would meet their requirements for graduation and help them in the pursuit of their chosen careers. When asked about mathematical connections in other areas, Yasmin answered,

> *I'm sure math is an integral part of medicine…My Calculus class is a little bit of a different kind of experience…I took a Biology-based Calculus… we calculated how often a synapse fires or the optimal existence point of a species … I thought that it was more useful, a lot more applicable* (than differential equations).

However, this desire to relate their course work with their interests is intertwined with another code, *mathematics as an educational tool.*

Mathematics as a Tool for Teacher Influence on Perceptions of Mathematics

The young women describe classroom experiences and teachers in which their perceptions of mathematics were changed. This change included their enjoyment and satisfaction in studying mathematics. The experiences described by the five girls included both positive and negative influences on their mathematics perceptions. Yasmin talked about both a positive and negative experience, one that in the end might have caused her to change her major:

> *I took third semester Calculus and then I took a differential equations class… I liked the Calculus class…I was like 'hey, you know, maybe I'll be a math major' … that changed about three weeks into Differential… I'm good at math. I enjoy doing it, I just didn't enjoy the professor… I decided it wasn't for me*

Teachers can have a monumental effect on young women's perceptions and enjoyment of mathematics.

Implications

This study provides another lens to view the literature concerning women's choices to pursue the advanced study of mathematics. All twelve young women in this study are good at math. Most of them enjoy doing math. These high achieving young women see the value in relating mathematics to other subject areas, yet they chose not to study advanced mathematics at the college and graduate levels. They chose instead to take 'math–based' courses that they feel are related to their majors or career interests.

Part of their lack of interest in pursuing mathematics in college may be related to the fact that most of these young women are interested in careers that either directly help people or appear to 'make a difference' in the possible lives of people. This is continuous with previous literature on young women's career choices (see Berenson, Michael, Vouk, 2006, Etzkowitz, Kemelgor, & Uzzi, 2000).

Even though all twelve of these girls were high achievers in mathematics during high school, none, of them majored in math. Out of the 174 girls in the first three camps, in which all the girls were selected to take Algebra I in middle school, the research team knows of only one girls who chose to major in mathematics. She is also pursuing a graduate degree in mathematics at a large research intensive university. This is surprising in the sense that the young women chose to pursue other areas of interest. However, the National Center for Education Statistics reveals that only about 1% of the degrees conferred are in mathematics and statistics (U.S. Department of Education, 2006). This leads the researchers to question why if the young women are so good in mathematics, and are aware of their abilities, do they choose to not pursue mathematics as a major?

As a result of this research, there are some implications that need to be considered in the larger scope. First, it may be necessary for teachers, counselors, and mathematicians to be more involved in educating students about what types of careers are available for math majors after college. This issue has been addressed in the computer science literature as well. For example, Margolis and Fisher (2003) suggest that providing students with a wide variety of experiences early in their education for examining how technology (or in the case of this study, mathematics) can be used in careers or in practice will attract more students to the field. According to Piatek-Jimenez (2008) the top three careers listed by senior mathematics majors for people with Bachelor's degree in mathematics were (1) teacher, (2) actuary/insurance underwriter, and (3) statistician. She went on to further state that the types of responses "demonstrated a shallow understanding of the career and posed doubt whether or not these careers were valid options" (pp.3).

Second, the young women in this study appear to have more interest in mathematics courses at the college level that are connected to situations that are more 'realistic'. The young women show more excitement for mathematics that is connected to their chosen career or majors. Therefore connecting mathematics course to more realistic contexts and providing the students with problems set within those contexts at the undergraduate level may also draw more students to the study of math. The researchers know that this is happening in some places. Zena talked about biology-based calculus class, and Dr. Todd Lee at Elon University is making connections to biology in his differential equations class (personal communication, February 2009).

Finally, it is extremely important for educators at the undergraduate level to remember that they still have an impact on students' perceptions of mathematics. A course or professor can

influence students to continue to study in a particular field, or they may influence that student to leave the field (Lovitts, 2001). The experiences that students have at the different educational levels, including elementary school through undergraduate mathematics courses can affect their perceptions. While student in high school may have an immediate turn around to a new class and new teacher following a negative experience, students at the undergraduate level may not. This may mean that a single negative experience in mathematics can make a young woman change her mind about studying a specific field (Lovitts, 2001). Bad experiences with faculty include a wide range of experiences. Students in Lovitts study found that faculty members who were cold, intimidating, and lacked personal connections could lead to bad experiences. Further, they felt that professors who inhibited personal, intellectual and profession development could cause a student to rethink their decisions concerning study in a specific field.

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