The Experiences of Female High School Students and Interest in STEM: What Factors Lead to the Selection of an Engineering or Computer Science Major

1. Abstract

STEM (Science, Technology, Engineering, and Math) education creates critical thinkers, increases science literacy, and enables the next generation of innovators, which leads to new products and processes that sustain our economy (Hossain & Robinson, 2012). We have been hearing the warnings for several years, that there simply are not enough young scientists entering into the STEM professional pathways to replace all of the retiring professionals (Brown, R., Brown, J., Reardon, & Merril, 2011; Harsh, Maltese, & Tai, 2012; Heilbronner, 2011; Scott, 2012). The problem is not necessarily due to a lack of STEM skills and concept proficiency. There also appears to be a lack of interest in these fields. Recent evidence suggests that many of the most proficient students, especially minority students and women, have been gravitating away from science and engineering toward other professions (President’s Council of Advisors on Science and Technology, 2010).

The outcome of this qualitative research study is an attempt to determine how high schools can best prepare and encourage young women for a career in engineering or computer science. This will be accomplished by investigating what courses, activities and experiences appear to encourage female high school graduates to pursue an engineering or computer science major, what common characteristics are shared by female engineering/computer science majors who remain in the program after one full year of coursework and what characteristics are shared by professional women who have a career as an engineer or work in the computer science fields. The research will be conducted via interviews that will be transcribed and analyzed to determine themes and patterns.

2. Project Description

The purpose of this study is to attempt to identify what high school experiences positively influence a young women’s decision to pursue a degree and subsequent career in a STEM field, especially in the areas of engineering and computer science. The study seeks to contribute to the body of research by interviewing groups of young women that represent transitions through three distinct phases of STEM educational and career paths; high school graduation, completion of first year of college and professional women who have at least one year of sustained employment in an engineering or computer science job.

A good deal of educational research has been conducted on the persistence of women in STEM majors and careers. These studies have focused mainly on GPA, standardized test scores, response to failure, mentors, gender disparity and financial aid (Gorman, Durmowicz, Roskes & Slattery, 2010; Inzlicht & Ben-Zeez, 2003; Margolis, Fisher & Miller, 2000; Vest, 1999; Whalen & Shelley, 2010), but there is limited research on what experiences at the high school level propel these young women into the STEM fields, specifically those in engineering and computer science. There is a need for further research to help guide curriculum reform, extracurricular opportunities and teacher preparedness that will in turn increase the number of young women who elect to pursue a STEM major.

Using the Social Cognitive Career Theory (SCCT) (Lent, Brown, & Hackett, 1994) and the Expectancy-Value Theory (Wigfield & Eccles, 2000) as guidelines to inform the qualitative research strategies, this study will examine ways that high schools can work to improve the self-efficacy and outcome expectations of young women in the STEM areas. This may in turn lessen the perceived barriers that make it difficult for them to achieve success and will also highlight methods of increasing young women’s self-assessment of their STEM abilities.

To determine what experiences positively influence a female high school student to declare a major in the engineering or computer science areas, the following research questions will be presented to female high school seniors, to young women who have completed one year of coursework in an engineering or computer science major and to women who have had at least one year in a career in the area of engineering or computer science: 1) What high school courses encouraged or introduced you to the STEM fields? 2) What high school activities encouraged or introduced you to the STEM fields? 3) In
what ways, if any, did your teachers encourage or assist you with your decision to pursue an engineering or computer science major? 4) What traits or skills were you taught in high school that helped you decide on an engineering or computer science major?

2.1 Product of Funded Activity.

The results of this project will be shared through a presentation at the University of Nebraska at Omaha Student Research Fair. The results will be published within the context of background elements of a doctoral dissertation in Educational Leadership and a manuscript publication in a peer-reviewed journal.

2.2 Contribution to student’s graduate studies

Each day I receive a Google alert that speaks to the lack of women in STEM fields, why this is a concern along with a few success stories. As a veteran science teacher and the Chair of the Marian High School Science Department, I have had more than 23 years of experience teaching students in an all female, college prep school. I have witnessed first hand the aversion that many young women show to the STEM careers. This is a source of frustration and disappointment as I see the hesitancy or even a fear exhibited by these women when considering a major in the areas of engineering or computer science. As their teacher, I know that it is not a lack of ability, for these girls have already demonstrated the intelligence and inquisitiveness to excel in these areas.

I propose that one way to change this disturbing trend is to make the high schools bear some of the responsibility for promoting STEM careers and ensuring that students have both the ability and fortitude to enter into these challenging careers. This study will help develop a guide of best practices that high schools can implement to prepare their students, particularly young women, to enter into these career paths. The knowledge gained in this study will be used personally in my own teaching career, at Marion High School, and in my dissertation and will be shared with other professionals to increase the number of young women who intentionally enter into the fields of engineering and computer science and succeed. The results of this study may shape how STEM education is taught at the high school level and how to motivate and encourage young women to pursue these careers.

2.3 Contribution to the field: Conceptual importance.

STEM jobs in the United States have grown more than three times faster than non-STEM jobs, and this pace is not projected to slow through the next decade (Langdon, Mckittrick, Beede, Khan, & Doms, 2011). These jobs require technical expertise, specialized training, or higher education that the average worker in the United States lacks, resulting in a critical shortage of STEM workers (Brown, et al., 2011). In order to increase the interest in mathematics and science fields, President Obama launched the “Educate to Innovate” initiative in 2009. A key component of this initiative is to “broaden participation to inspire a more diverse STEM talent pool”(Chu, Barret & Zaslav, n.d.). One of the groups targeted by this effort was women and girls. Further support was given through the Office of Science and Technology Policy, who in collaboration with the White House Council on Women and Girls, is dedicated to increasing the participation of females in the STEM fields by increasing the level of engagement, providing encouragement, mentoring and supporting efforts to retain women in the STEM workforce. (Women in STEM, 2012)

If male and females receive equal preparation, then why are the numbers so low for women in the engineering and computer science fields? Research in this area is ongoing. Legewie and DiPrete (2014) wrote that high school environments play an important role instilling a sense of value in STEM in students and these effects are stronger for girls than for boys. They found that girls are strongly influenced by a science-intensive school environment that stimulates interest in science and also reduces the power of gender stereotypes that tend to be a concern in STEM fields. They also postulated that high school girls make decisions regarding future careers using two main sources, 1) prior beliefs about their ability and suitability in math and science and 2) the experiences they obtain in high school.

In light of the above evidence related to the low numbers of female STEM college students and graduates, the purpose of this study becomes relevant in today’s educational climate. I believe
that the results of this study, in the form of a bank of common experiences, courses and activities that
fuel the interest and desire of female students to continue in the STEM field, could be implemented
into the existing STEM education programs at high schools. If nothing else, it will provide high
schools with a starting point to infuse excitement, interest and experiences that are needed to prepare
young women for the transition to college and the work force.

3. Methodology.

3.1 Participants.

The study will include interviews of 15 women across three stages of the STEM pathways; 5 high school
graduates planning to major in an engineering or computer science field, 5 women who have completed
their first full year of engineering or computer science collegiate courses and 5 women who are
established with at least one year in an engineering or computer science occupation. The UNO STEM
Community Chairs and the UNO STEM Leadership Team will be asked to refer possible interviewees for
the study.

3.2 Data collection procedure.

Each woman who accepts the invitation will be contacted and interviewed. The interview will be
recorded and notes will also be taken. Four broad questions along with a completely open ended
follow up question (see below) will be asked of each interviewee with probing questions being asked
to maintain the flow of the interview.

The interview will be allowed to progress naturally. If more clarification about a particular answer is
needed, further probing questions will be developed as the interview progresses in order to best
determine what the interviewee is actually thinking/saying about her STEM experiences in high
school. General research questions for the study are as follows: 1) What high school courses
encouraged or introduced you to the STEM fields? 2) What high school activities encouraged or
introduced you to the STEM fields? 3) In what ways, if any, did your teachers encourage or assist you
with your decision to pursue an engineering or computer science major? 4) What traits or skills were
you taught in high school that helped your decide on an engineering or computer science major?
5) What other comments/thoughts that you feel I need to know about this topic?

3.3 Data analysis procedure.

The audio from each interview will be recorded, transcribed using Inqscribe software and notes will
be added to highlight ideas and concepts that develop. The notes will be analyzed to identify
common themes, experiences or events that positively contributed to the women’s interest in STEM
well as traits that led to persistence in their majors and/or careers. The themes will be analyzed
using both technology and by hand to gain the best overall results. When common themes and
general answers to the questions are determined, a subset of the interviewees will be asked to
determine if they agree with the outcomes in the attempt to provide validity to the study.

4. Projected Project Time Line.

Spring 2016 --------- Obtain necessary project materials; compile list of possible interviewees
Summer 2016 --------- Gain IRB approval. Assemble interviewees, gain their permission. Conduct and
transcribe interviews.

Fall 2016 ------------- Conduct data analysis. Conduct panel discussion for validity. Finalize dissertation
Spring 2017---------- Present at UNO Student Research and Creative Activity Fair; prepare manuscript
for research journal submission.

5. Student /Faculty Roles.

I, as the student, will be responsible for soliciting, selecting and interviewing participants. I will also be
responsible for transcribing the interviews, analyzing the data, developing the results and conducting a
discussion with participants to develop validity. Finalizing my dissertation for defense and preparing my
results for publication will be the concluding steps of this project.

The role of my faculty mentor, Dr. Neal Grandgenett, will be assisting in developing a list of
interviewees, overseeing and reviewing my data collection, research design, results and written
analysis of research as well as providing feedback throughout this process.
References


Women in STEM. (2012). Retrieved November 6, 2015, from https://www.whitehouse.gov/administration/eop/ostp/women

Note: The UNO College of Education and Office of STEM Education will provide the following tools and materials to support research projects conducted under the supervision of the graduate student’s faculty mentor: shared lab space in Roskens Hall and computers and equipment for data processing, transcription, and analysis.

Table 1: Budget and Budget Justification

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January 9, 2015

Dear GRACA Selection Committee,

It is my honor and privilege to write this letter of support for Ms. Sharon Genoways, in her application for GRACA funding for her research project entitled: “The Experiences of Female High School Students and Interest in STEM: What Factors Lead to the Selection of an Engineering or Computer Science Major”. As a Professor of Teacher Education in the College of Education, and the Haddix Community Chair of STEM Education, I have had the opportunity to both teach and work with Ms. Genoways. She is one of the most outstanding and gifted graduate students that I have had the pleasure to work with in my 27 years as a faculty member at UNO. Her proposed GRACA proposal is well developed, and I had the pleasure of helping her to refine her proposal narrative. The topic itself (the STEM interests of female students) is truly the culmination of a life long interest and dedication that Ms. Genoways has pursued as a science teacher and chairperson of the science department at Marion High School, an all women high school well known for their STEM excellence. This GRACA effort will not only lay a strong foundation for her doctoral dissertation work, but will also surely contribute to research critical to the United States.

A GRACA scholarship would be well deserved. Ms. Genoway’s instructional, administrative and organizational abilities are indeed exceptional, and she is an engaging, energetic, and uplifting doctoral student. She has prepared well for this GRACA project and I have carefully reviewed her proposal and provided several edits and suggestions. Her work is uniquely her own, but it is certainly synergistic within my own STEM Education research and interests, so I am very excited to help to guide her and to support her in this effort. Her GRACA research builds on what she has learned in previous UNO graduate classes.

In addition to her exceptional work in UNO graduate classes, Ms. Genoways has also participated in various UNO related research projects, including within a National Science Foundation curriculum development project on educational robotics (SPIRIT) as well as work with wearable technologies (WearTec). She has been an extremely well organized and contributing graduate student, where I have seen first hand her talents in research, teaching, and presentation. She is certainly well skilled, and will be able to complete the GRACA project within the context of the designated timelines. I will also help her to ensure that all IRB requirements are met and approvals received from the UNMC IRB office.

It should be easy to see how I feel about Ms. Genoways and her exceptional graduate student talents. This GRACA proposal is just one more indication of her continued excellence, and her steadfast commitment to helping young women enter and achieve in the STEM pathways. I feel highly confident in recommending her for the GRACA program, and I am really looking forward to working closely with her on the project. Please do not hesitate to call me to discuss Ms. Genoways or her GRACA proposal in further detail. I would greatly welcome the opportunity to work with her on this excellent project.

Sincerely,

Neal Grandgenett, Ph.D.
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