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The Top Three Motivational Factors for Students Entering Pre-engineering or Engineering Programs in Public Four-year Higher Education Institutions in Virginia

Dr. James Irvin Cooke Jr., Virginia State University

Director of Assessment and Senior Capstone Experiences Program Coordinator of Information Logistics program Department of Technology Virginia State University

Dr. Jinmyun Jo, Virginia State University

Virginia State University, Associate Professor

Virginia Tech, Ph.D.

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James I. Cooke Jr and Jinmyun Jo
Virginia State University, Petersburg, VA 23806

I. Introduction

Science, technology, engineering, and mathematics (STEM) curricula is one of the hottest topics in education. The national focus is on recruiting students into STEM majors. For example, on December 6, 2010, President Obama spoke to the public at the Forsyth Technical Community College in Winston-Salem, North Carolina [1]. He stated that our generation's Sputnik moment was at hand. During the speech, he commented on the need for education for 21st century industries and increased manufacturing. During this speech, he discussed math, science and educational needs in preparing the workforce for 21st century industries.

There are many influences that affect a person's decision to enter a science, technology, engineering or mathematical (STEM) major. Individuals are motivated by the desire to maximize a positive affect or to minimize a negative effect [2]. Typical factors for a student's decision on a STEM major are ability, interest, self-efficacy, and educational experiences [3]. Parental educational levels, parental occupations, and family income are strong influences on a student [4]. These factors affect the student's values, formal and informal educational activities, and the student's interest and abilities. Parents serve as advisors and motivators to their children [5]. More than fifty percent of students enrolled in an engineering field if at least one parent or family member was an engineer [6].

This study was grounded in the social cognitive career theory (SCCT). Social Cognitive Career Theory (SCCT) was developed in 1994 by Robert W. Lent, Steven D. Brown, and Gail Hackett [7]. It is a theory that explains the three interrelated aspects of career development. The first aspect is how basic academic and career interests develop. The second aspect is how educational and career choices are made. The third aspect is how academic and career success is obtained. The theory incorporates interests, abilities, values, and environmental factors. SCCT is based on Albert Bandura's general social cognitive theory.

This study implemented a non-experimental, quantitative methods approach to data collection and analysis. A cross-sectional survey design was used as it was the most effective method in collecting large quantities of data quickly and efficiently. The study was non-experimental because the independent variables were not manipulated in any way and there was no control group to compare the results of the study. The independent variables used in the study were gender and ethnicity. The dependent variables were a) high school academic success, b) influences, c) personal interests, and d) self-efficacy. The study was developed to reveal the various motivational factors that impacted students' decisions to enroll in an engineering major at higher education institutions. The next sections describe population and sample size, instrument and reliability analysis, limitations, and assumptions. The paper ends with a summary and a conclusion.

II. Population and sample size

The population for the study was engineering and pre-engineering students at four year public colleges and universities in the Commonwealth of Virginia. The sample for this study was engineering and pre-engineering students at four year public colleges and universities in Virginia in fall 2014 who participated in the study. There are fifteen public colleges and universities throughout the Commonwealth of Virginia. Thirteen of these higher education institutions have a pre-engineering or engineering program. New College Institute was also selected because it has an Academy for Engineering and Technology that was supported by Virginia State University in 2014.

Private universities and colleges were not selected because of the time frame of the study. The twenty-three Virginia community colleges were not selected either. In order to earn an engineering degree, a student would have to transfer to a four year institution after completing the program at the community college. Therefore, the study focused on the four year institutions. The sample was a purposive sample because the subjects were chosen because they are enrolled in an engineering or pre-engineering program. Purposive sampling is a non-probability sample because the subjects were selected by the judgment of the researcher [8].

III. Instrument and reliability analysis

A survey developed and used by Christopher H. Porter in his 2011 dissertation at Clemson University was used [9]. Dr. Porter's permission for modification and use of the survey was obtained. Dr. Porter's study looked at engineering students and science students, whereas, this study only looked at engineering and pre-engineering students. Therefore, some questions were customized for engineering and pre-engineering students and some questions were removed.

This study uses Cronbach's alpha for Reliability Analysis. Cronbach's alpha splits the data in two in every possible way and computes the correlation coefficient for each split [10]. The average of the coefficients is Cronbach's alpha. The interpretation of Cronbach's alpha is shown Table 1. If the value is below 0.7 then the internal consistency is weak. A value between 0.7 and 0.8 is acceptable but a value between 0.8 and 1.0 has a strong internal consistency. The reliability analysis for the survey for this study was 0.814.

IV. Limitations

The study was a cross-sectional study, occurring for a short period of time; a snap shot of engineering or pre-engineering students enrolled in four-year public higher educational institutions in the Commonwealth of Virginia in the 2014 fall semester. It did not include any students enrolled in engineering or pre-engineering programs in other. Sample size, maturation of students, and time constraints were additional limits on this study. Maturation may have been a factor in the students' answers because their memory of the reasons for entering an engineering or pre-engineering major may have been different than the actual reasons they had when they were in high school. Time constraints were a limitation because five weeks was dedicated to data collection. The sample was also a limitation. It did not include any students in the other

forty-nine states or any engineering or pre-engineering students in other countries. It also did not include engineering or pre-engineering students in private four-year colleges or institutions or community colleges. Generalization to national engineering or pre-engineering students is difficult because of the sample size.

Table 1. Interpreting Cronbach's alpha

Cronbach's alpha	Internal consistency
$\alpha \geq 0.9$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptable
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

V. Assumption

There were a few assumptions regarding the study on engineering and pre-engineering students. The first assumption was that the students answered the survey questions honestly and thoroughly. The second assumption was that only engineering or pre-engineering students answered the survey questions. The third assumption was that the researcher had the support of the engineering or pre-engineering program administrators in encouraging students to participate in the study. The fourth assumption was that all engineering or pre-engineering students had and actively used email programs in order to obtain the link to the survey.

VI. Results and discussion

It is not known how many surveys were sent out to students because a designated person or persons at each college and university launched the survey at his/her respective campus. The person or persons did not communicate to the researcher the total number of surveys that were sent out. Nonetheless, 416 respondents initially started the survey. After the surveys were completed and the responses were reviewed, the researcher noticed that several participants had either failed to identify their major or were in a non-engineering major. There were twenty-four participants in twelve non-engineering majors that were deleted including project management, agricultural science, and criminal justice. There were seventeen participants who were deleted because they did not identify any major. This brought the number of participants down from 416 to 375 for statistical analysis.

The participants attended high school in twenty-four states, as well as, in foreign countries. Out of the respondents, 70.65% of the participants completed high school in Virginia. Sixty-seven percent of the respondents were male while 33% were female. Fifty-one percent of the participants were African American. Thirty-six percent of the participants were Caucasian. Six percent of the participants were multi-racial, 5.2% were Asian, 0.82% were Hispanic/Latino, 0.27% were Native American/Alaskan Native and 0.27% were Pacific Islander/Hawaiian Native.

There were fourteen engineering majors identified by the survey respondents. These included Aerospace, Civil, Industrial, Manufacturing, Mechanical, Computer, and Electrical Engineering. Twenty percent of the survey respondents enrolled in the major of Industrial Engineering. Twenty percent of the survey respondents were in Civil Engineering. Sixteen percent of the respondents were in Mechanical Engineering. Eight and one-half percent of the respondents were in Computer Science and 7.2% were in Computer Engineering. Eight and one-half percent of the respondents were in Electrical Engineering.

Thirty-nine percent of the Caucasian respondents and 2.67% of the African American respondents were enrolled in Civil Engineering. Twenty-seven percent of the African American respondents and 3.7% of the Caucasian respondents were enrolled in Mechanical Engineering. Twenty-three percent of the Caucasian respondents and 16.58% of the African American respondents were in Industrial Engineering. Thirteen percent of the African American respondents were enrolled in Electrical Engineering and 13% of the African American respondents were enrolled in Manufacturing Engineering. One and one-half percent of the Caucasian respondents enrolled in Electrical Engineering and no Caucasian respondent was enrolled in Manufacturing Engineering.

Twenty-three percent of the male respondents and 8.9% of the female respondents enrolled in Civil Engineering. Twenty-three percent of the female respondents and 15.66% of the male respondents chose Industrial Engineering as their major. Twenty-one percent of the male respondents and 5.69% of the female respondents enrolled in Mechanical Engineering. Twelve percent of the female respondents and 5.62% of the male respondents chose Computer Science as a major. Ten percent of the male respondents and 4.88% of the female respondents enrolled in Electrical Engineering.

Table 2 presents the top three influences on survey participants. Eighty-three percent of the respondents selected personal interests as an influence on their decision to pursue an engineering major. Seventy percent of the respondents selected career opportunities as an influence on their decision to pursue an engineering major. Forty-eight percent of the respondents selected family members as an influence on their decision to pursue an engineering major. The categories of factors that influenced the respondents' enrollment decisions can be seen in Figure 1.

Eighty-seven percent of the Caucasian participants selected personal interests as an influence on their choice of major. Eighty-one percent of the Caucasian participants chose career opportunities as an influence. Fifty-five percent of the Caucasian participants chose family members as an influence. Sixty-six percent of the African American participants chose personal interests as an influence on their choice of major. Forty-eight percent of the African American participants selected career opportunities as an influence. Thirty-five percent of the African American participants chose family members as an influence.

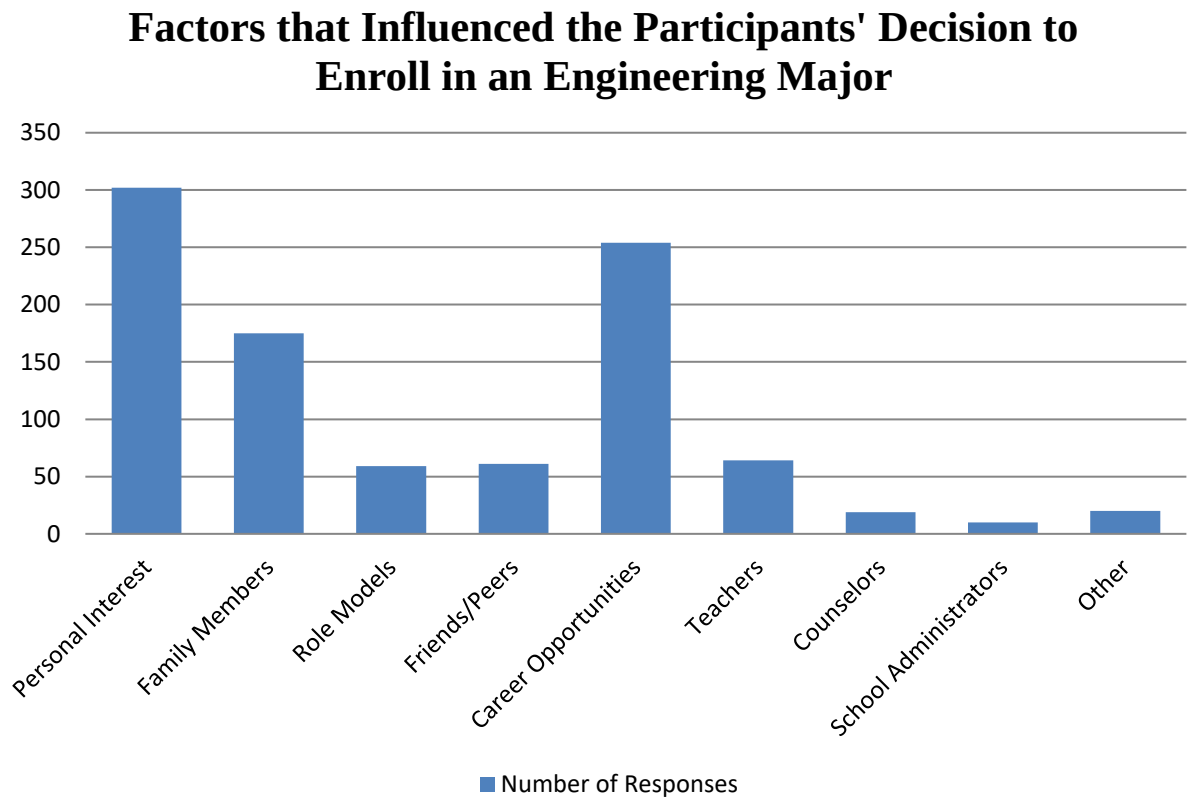

Figure 1. Frequency analysis for factors that influenced the participants' decision to enroll in an engineering major

Eighty percent of the males chose personal interests as an influence on their choice of major. Sixty-four percent of the males chose career opportunities as an influence. Forty-three percent of the males chose family members as an influence. Sixty-eight percent of the females chose personal interests as an influencing factor on their choice of major. Sixty-five percent of the females chose career opportunities as an influence. Forty-six percent of the females chose family members as an influence.

Table 2. Top Three Influences on Survey Participants

Respondents	Personal Interests	Career Opportunities	Family Members
Total	83%	70%	48%
Caucasian	87%	81%	57%
African American	66%	48%	35%
Male	86%	64%	43%
Female	68%	65%	46%

Some of the survey questions looked deeper into the influence of family members on the respondents' decisions to enter an engineering or pre-engineering program. Table 3 shows that Fifty-six percent of the participants indicated that their mother/female guardian had a strong positive influence on their choice of major. Fifty-one percent of the participants stated that their father/male guardian had a strong positive influence. Forty-five percent of the participants stated their sibling(s) did not have an influence on their decision to major in an engineering program.

Fifty-four percent of the African American respondents and 40% of the Caucasian respondents indicated their mother/female guardian had a strong positive influence on their choice of major. Thirty-one percent of the Caucasian respondents and 16.6% of the African American respondents stated their mother/female guardian had a somewhat positive influence on their decision to enroll in an engineering major. Twenty-one percent of the Caucasian respondents and 12.3% of the African American respondents felt that their mother/female guardian did not have any influence on their choice of major.

Fifty percent of the Caucasian respondents and 40.7% of the African American respondents indicated their father/male guardian had a strong positive influence on their choice of major. Twenty-eight percent of the Caucasian participants and 13.9% of the African American respondents stated their father/male guardian had a somewhat positive influence on their decision to enroll in an engineering program. Twenty-four percent of the African American respondents and 14.9% of the Caucasian respondents specified their father/male guardian did not have any influence on their decision.

Forty-seven percent of the Caucasian respondents and 31.6% of the African American respondents stated that their sibling(s) did not have an influence on their decision to enroll in an engineering major. Twenty-eight percent of the African American participants and 14.9% of the Caucasian participants specified that their sibling(s) had a strong positive influence on their decision.

Forty-seven percent of the male respondents and 48.8% of the female respondents stated that their mother/female guardian had a strong positive influence on their choice of major. Twenty-one percent of the male respondents and 24.4% of the female respondents indicated that their mother/female guardian was a somewhat positive influence on their decision. Twenty-three percent of the male respondents and 8.9% of the female respondents believed their mother/female guardian did not have any influence on their decision.

Forty-three percent of the male respondents and 47.2% of the female respondents indicated that their father/male guardian had a strong positive influence on their decision. Twenty-one percent of the male respondents and 17.1% of the female respondents specified that their father/male guardian had a somewhat positive influence on their choice of major. Twenty-four percent of the male respondents and 17.1% of the female respondents indicated that their father/male guardian did not have any influence on their choice to enroll in an engineering major.

Forty-one percent of the male respondents and 33.3% of the female respondents stated that their sibling(s) did not have any influence on their choice of enrolling in an engineering major. Twenty-two percent of the male respondents and 24.4% of the female respondents specified that

their sibling(s) had a strong positive influence on their major. Twenty-one percent of the males and 14.6% of the female respondents indicated that their sibling(s) had a somewhat positive influence on their choice of major.

Table 3. Breakdown of Influences of Family Members

Respondents	Influence of Mother/Female Guardian	Influence of Father/Male Guardian	Influence of Siblings	Influence of Level of Support at Home	Level of Influence
Total Participants	56%	51%	22.3%	57%	Strong
	21.6%	19.3%	18.4%	29%	Somewhat
	17.9%	19.9%	45%	10%	None
Caucasian	40%	50%	14.9%	58%	Strong
	31%	28%	20%	26%	Somewhat
	21%	14.9%	47%	6%	None
African American	54%	40.7%	28%	44.4%	Strong
	16.6%	13.9%	17.3%	25.7%	Somewhat
	12.3%	24%	31.6%	9%	None
Male	47%	43%	22%	49%	Strong
	21%	21%	21%	27%	Somewhat
	23%	24%	41%	12%	None
Female	48.8%	47.2%	24.4%	52%	Strong
	24.4%	17.1%	14.6%	22.8%	Somewhat
	8.9%	17.1%	33.3%	5.6%	None

Fifty-seven percent of the participants in the survey stated the home environment had a strong positive influence on their choice of major. Twenty-nine percent of the survey participants stated the home environment had a somewhat positive influence. Fifty-eight percent of the Caucasian respondents and 44.4% of the African American respondents indicated that the level of support at home had a strong positive influence on their choice. Twenty-six percent of the Caucasian respondents and 25.7% of the African American respondents stated that the level of the support at home had a somewhat positive influence on their choice of major.

Forty-nine percent of the male respondents and 52% of the female respondents indicated that the level of support in the home had a strong positive influence on their decision to enroll in an engineering major. Twenty-seven percent of the male respondents and 22.8% of the female respondents specified that the level of support at home had a somewhat positive influence on their choice.

VII. Summary and conclusion

The majority of the respondents (71%) attended high school in Virginia. Twenty-one percent graduated in 2014 and 21% graduated in 2013. Twenty-two and one-half percent of the respondents enrolled in a university or college in 2014 and 22% enrolled in 2013. Twenty percent of the respondents were 18 years old and 19.5% were 19 years old. Fifty-one percent of

the respondents were African American and 36% were Caucasian. Sixty-seven percent of the respondents were male and 33% were female.

There were fourteen engineering majors identified by the survey respondents. These included Aerospace, Civil, Industrial, Manufacturing, Mechanical, Computer, and Electrical Engineering. Twenty percent of the survey respondents enrolled in the major of Industrial Engineering. Twenty percent of the survey respondents were in Civil Engineering. Thirty-nine percent of the Caucasian respondents and 2.67% of the African American respondents were enrolled in Civil Engineering. Twenty-seven percent of the African American respondents and 3.7% of the Caucasian respondents were enrolled in Mechanical Engineering. Twenty-three percent of the Caucasian respondents and 16.58% of the African American respondents were in Industrial Engineering. Twenty-three percent of the male respondents and 8.9% of the female respondents enrolled in Civil Engineering. Twenty-three percent of the female respondents and 15.66% of the male respondents chose Industrial Engineering as their major. Twenty-one percent of the male respondents and 5.69% of the female respondents enrolled in Mechanical Engineering.

Eighty-three percent of the respondents chose personal interests as an influence on their choice of major. Seventy percent of the respondents chose career opportunities as an influence. Each of the four subcategories of Caucasian respondents, African American respondents, male respondents and female respondents listed the same three influences in the same order. The mother/female guardian had a significant relationship with the participants' decision to enroll in an engineering major whether it was based on gender or ethnicity.

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