AC 2011-2263: FACTORS INFLUENCING HIGH SCHOOL STUDENTS' TO PURSUE AN ENGINEERING BACCALAUREATE

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Factors Influencing High School Students to Pursue an Engineering Baccalaureate

Introduction

In the twenty-first century, students have myriad curricula that may be pursued in high schools. Curricula at specialized high schools have been developed for very specific areas of study when compared to the curricula at most comprehensive high schools. At comprehensive high schools, a general program of study is offered either in a college-preparatory curriculum or general/vocational curriculum. Depending upon the school district, as students matriculate to high school, they may be afforded more choices from which they can begin to tailor their education towards the future career they envision for themselves. Students in school districts offering numerous curricula to select from face further complications in the selection of a curriculum of academic study. There are many influencing factors that affect the choice of the academic curriculum that they select to pursue. At this point in their education, few students will have full understanding of the numerous curricula and the different disciplines. Therefore, it is very difficult for a student to make a highly-informed decision regarding the selection of the discipline that he/she is interested in pursuing in high school as well as in achieving academic success in the discipline selected.

Geographic location, socioeconomic status, parental work-related attitudes, families, peers, education, availability of occupational information, job market, difference in age, gender, and personal characteristics all influence career choice.[1,2, 3, 4] The myriad curricula offered in today's high schools increase the difficulty a student is confronted with in the selection of an appropriate discipline to study. It is unfortunate that some students are influenced in their decision by the present employment market's conditions, poorly informed advisors, deceptive education and career advertisements, and over estimating their knowledge in prerequisite coursework areas. The combination of these factors can adversely affect the proper selection of an academic discipline of study that will provide a stable and satisfying long-term career.

Research has indicated that students who are most likely to choose engineering majors and complete degree requirements are those who hold positive perceptions toward engineering, have self-efficacy for the study of engineering, and have interests in science and technology.[5, 6, 7, 8] On the flip side, lack of confidence in student's abilities to complete an engineering degree, negative impressions of engineering, and little or no enjoyment in studying mathematics and science lead students to avoid selecting an engineering major or withdrawing from engineering studies.[5, 6, 7, 8,9] The numbers of engineering students were found to be declining during the past two decades, and engineering education faced with unprecedented pressures to change due to globalization of economy, society, and technology.[10]

Scope

This research was conducted to assist educators and educational administrators in understanding student interest in the engineering discipline at the high-school level. The research was conducted at four Clark County School District (CCSD) Career and Technical Academies (CATA). The CCSD is located in southern Nevada and is the fifth largest school district in the United States.[11]

The objective of the research presented in this paper is to investigate characteristics and academic interests of CCSD CATA students enrolled in engineering curricula. Various factors were investigated that influenced a student to attend a CATA engineering program and the student's choice to pursue a baccalaureate in engineering.

Hypotheses

Four research hypotheses were formulated for this study. They are: (1) students whose parents or family members who are employed or have been employed in an engineering related industry are more likely to select engineering as an area of study in high school; (2) students whose parents or family members are employed in or have been employed in an engineering related industry are more likely to plan to pursue an engineering baccalaureate; (3) students who are enrolled in the high-school pre-engineering curricula plan to pursue an engineering baccalaureate; (4) students planning to pursue an engineering baccalaureate is independent of their belief that employment is readily available in their engineering discipline.

Survey

This research is a part of a larger exploratory study based upon data collected in November 2009 by CCSD from 880 students enrolled in four CATAs. The data analyzed and presented in this paper is considered to be secondary data. The data is derived from high school students enrolled in curricula relating to architecture, construction, and engineering that is offered by the four CATAs. Depending upon the institution, the CATA architecture, construction, and engineering curricula were either college preparatory or vocational. The data investigated in this paper are from students that are enrolled in one of the college-preparatory engineering curricula. Each CATA has a slightly different name for the engineering curriculum they offer; to avoid confusion, in this paper they are referred to as engineering curricula. The four CATAs were: Advanced Technologies Academy, East Career and Technical Academy, Northwest Career and Technical Academy, and Southeast Career and Technical Academy. Enrollment in a CATA is obtained through a competitive process. The curricula vary across the CATAs, and not all curricula are offered at every CATA. Of the 880 respondents, 724 respondents' surveys were sufficiently complete for analysis. Of the usable surveys, 288 respondents were enrolled in college-preparatory engineering curricula. In order to summarize the information provided by the respondents, the data collected was entered into a spreadsheet-based database that was used to perform descriptive analysis and to generate tables and charts. All the variables were assigned numerical values to represent them correctly and to simplify the data entry process. For example,

the questions with 'yes' and 'no' responses were entered in the database by assigning 1 = yes and 0 = no.

Table 1 provides a summary of data collected about the students and the curricula that they were enrolled in at the four CATAs. Only the students enrolled in general engineering and entertainment engineering curricula were considered in analyses investigating the hypotheses. Both of these curricula were the college-preparatory engineering curricula.

Table 1. Student enrollment by curricula at Career and Technical Academies.

Curriculum	Advanced Technologies Academy	East Career & Technical Academy	Northwest Career and Technical Academy	Southeast Career Technical Academy
Architectural Design	65	4	15	57
Construction Management	0	81	65	1
Construction Technology	0	53	8	26
General Engineering	58	6	220	0
Entertainment Engineering	0	2	2	0
Other	24	10	11	16
Total	147	156	321	100

Results

The distribution of gender for the engineering curricula at the four CATAs is shown in Figure.1. The enrollment is strongly male dominated, with 74 percent of the students being male.

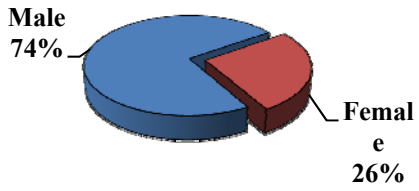

Figure 1. Distribution of male and female.

The distribution of student ages and their high-school grades is shown in Figure 2. Seventy-five percent of the students were below the age of 17. The age distribution is effected by the opening of the CATAs. The first CATA was opened in 2007, followed by a one-year sequential opening of the remaining new CATAs each subsequent year. Only grades 9 and 10 students are initially admitted when a new CATA is opened. An exception, the Southeast CATA was converted from an existing vocational high school and offered grades 9 through 12 from the beginning. For the 288 students enrolled in engineering curricula, 20 percent of the students were enrolled in grade 9, 35 percent of the students in grade 10, 28 percent of the students in grade 11, and 17 percent of the students were enrolled in grade 12.

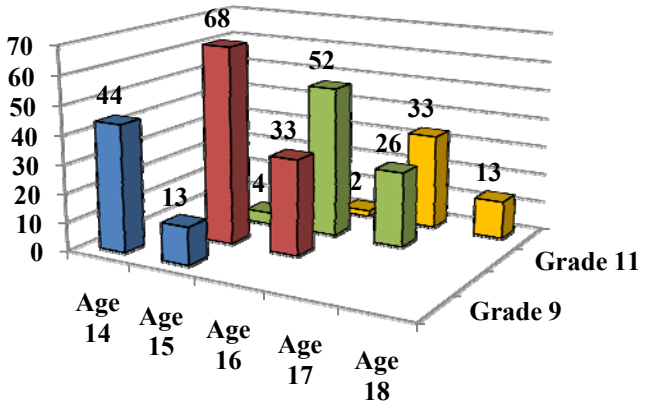

Figure 2. Distribution of age and grade.

Table 2 provides a summary of the results obtained from students regarding actions taken prior to enrollment in a CATA engineering program. Prior to enrollment, almost as many of the students talked to students presently enrolled in the program about the program as students who didn't make such inquiries. Less than a quarter of the students talked to a program teacher prior to enrolling in it. Fifty-nine percent of the students listened to a recruiter's presentation on the CATA program while they were in middle school.

Table 2. Students' actions prior to enrollment in a CATA engineering program.

Action	Yes (%)	No (%)
Talk to any student(s) presently enrolled in a CATA engineering program prior to your enrollment	47	53
Talk to a program teacher in a CATA engineering program prior to your enrollment	22	78
Listen to a recruiter's presentation on the CATA's programs that you are presently enrolled in while in middle school	59	41

Students enrolled in architecture, construction, and engineering curricula were asked to indicate disciplines in which they wished to pursue a baccalaureate. They were asked to select a first, second, and third priority baccalaureate. Figure 3 shows the results for the first priority selected by the students. The blue bars represent the 255 students out of 288 students who were enrolled in engineering curricula. The red bars represent 376 students enrolled in other CATA curricula who selected as their first priority to pursue one of the baccalaureates listed in the questionnaire. Seventeen percent of the students enrolled in engineering curricula selected as their first priority to pursue a baccalaureate in mechanical engineering. Similarly, 12 percent of the students indicated civil engineering, architectural engineering, and architecture as their first priority. Twenty-nine percent of the students who were enrolled in non-engineering curricula indicated as their first priority to pursue a baccalaureate in architecture. Forty-three percent of students who were enrolled in non-engineering curricula indicated as their first priority to pursue an engineering baccalaureate.

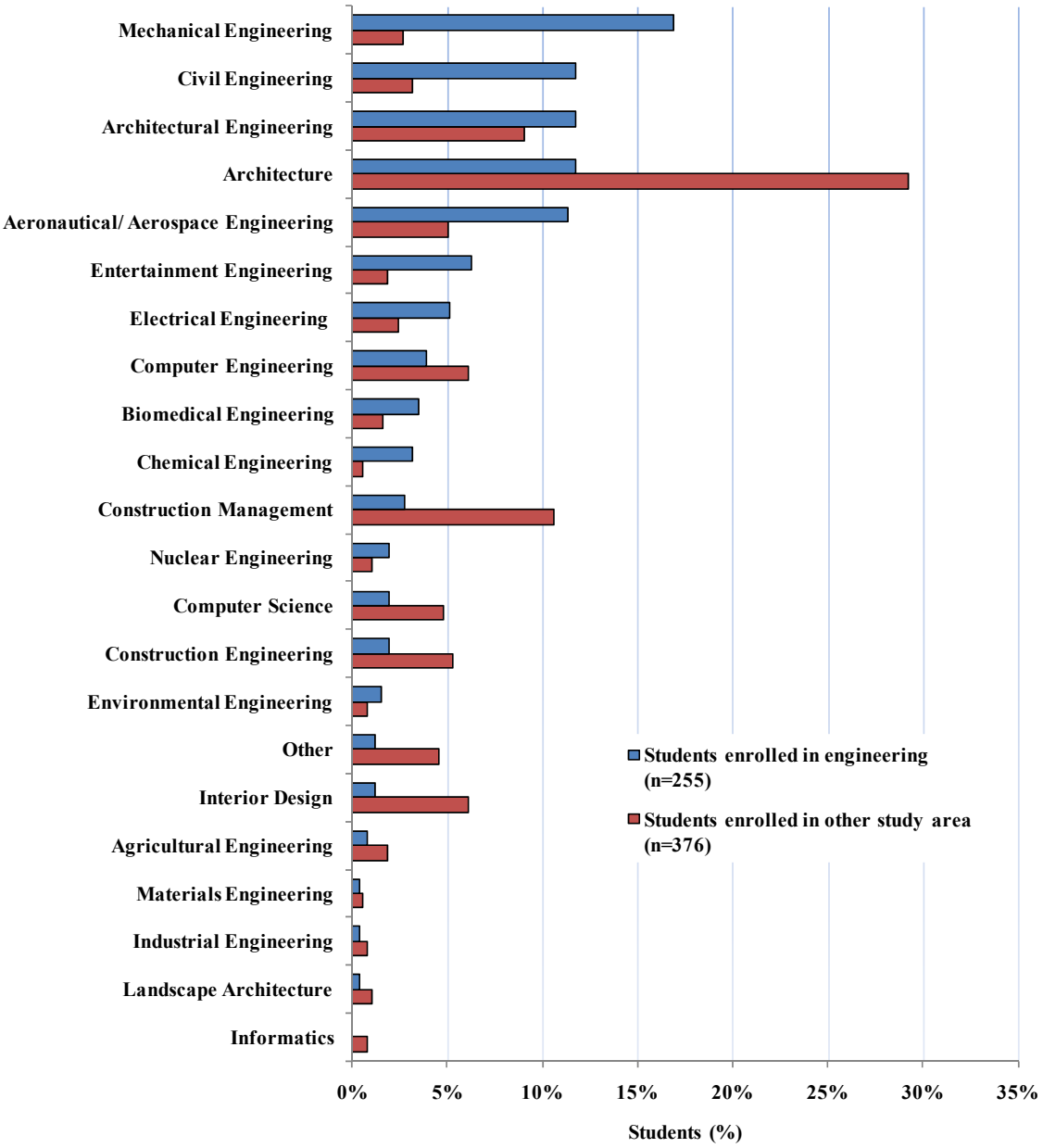

Figure 3. Baccalaureate disciplines selected as first priority by students.

Table 3 provides a summary of the results obtained for students enrolled in engineering curricula in response to the question that determined what family members and relatives had previously been employed in or were presently employed in engineering-related areas. Among the family members, fathers and uncles were found to be most employed in engineering-related work.

Table 3. Family members and relatives employed in engineering-related work.

Family Members									
Father	**Uncle**	**Grandfather**	**Cousin-male**	**Aunt**	**Brother**	**Mother**	**Cousin-female**	**Sister**	**Grandmother**
95	73	57	45	18	16	14	12	8	5
27.7%	21.3%	16.6%	13.1%	5.2%	4.7%	4.1%	3.5%	2.3%	1.5%

Table 4 presents the educational attainment level of family members for students enrolled in engineering curricula.

Table 4. Education levels of family members.

Education	Father (%)	Mother (%)	Brother (%)	Sister (%)
Doctorate	4	2	4	1
Master's	16	14	1	5
Bachelor's	13	23	16	15
Associate's	5	8	5	5
Some College but did not obtain degree	18	22	13	16
High School or GED	31	23	38	43
Some High School	9	5	7	4
Less than High School	4	3	17	9

The post-graduation intentions of 283 students in CATA engineering curricula are shown in Figure 4. Fifty-eight percent indicated that they planned to matriculate to a bacculaureate program. When a student checked more than one category regarding their post-graduation intentions, the student's response was assigned to the undecided catergory with respect to their post-graduation intentions. Eleven percent of the students checked more than one category. Twelve percent of the students selected the undecided category. When combined, these two groups yielded a value of 23 percent undecided. Likewise, students who wanted to join the Armed Forces, enter the work force, or enter a two-year terminal technical degree were 12 percent, 4 percent, and 3 percent respectively. Forty percent of male students planned to matriculate to a baccalaureate degree program versus 18 percent of the female students.

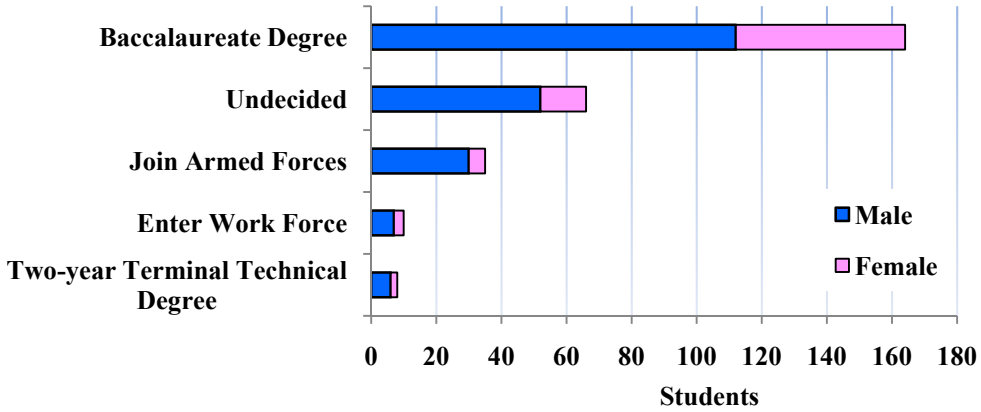

Figure 4. Post-graduation intentions of students in CATA engineering curricula.

The cross tabulation of a family member's influence versus employment percentage of a family member in engineering is shown in Table 5. The results presented in this table are based upon the suvey question, "Check all of the following individuals and factors that have influenced your decision to select any of the following areas of study in high school." and the survey question, "Check all of the family members and relatives who have previously worked or presently work in the following areas." The result shows that 39 percent of fathers were employed in engineering when the father influenced a student to select engineering. At the same time, 5 percent of mothers, 5 percent of brothers, 2 percent of sisters, 22 percent of uncles, 5 percent of aunts, 19 percent of grandfathers and 1 percent of grandmothers were also employed in an engineering-related area. Likewise, when the uncle influenced a student to select engineering, 31 percent of the uncles were employed in engineering whereas only 26 percent of the fathers were employed in the engineering-related area. The result shows that if a father, uncle, and grandfather were employed in engineering, then there is a high probability that the other family members will recommend that their children go into engineering.

Table 5. Cross tabulation of influencing family member to choose engineering vs. percentage of family members employed in engineering.

Influencing Family Member	Employment percentage							
	Father	Mother	Brother	Sister	Uncle	Aunt	Grandfather	Grandmother
Father	39	5	5	2	22	5	19	1
Mother	30	10	4	2	24	5	22	1
Brother	29	2	12	2	31	5	17	2
Sister	31	2	6	4	24	6	25	2
Uncle	26	4	3	1	31	6	27	1
Aunt	22	2	4	2	26	15	28	2
Grandfather	21	4	4	0	25	7	38	1
Grandmother	29	7	7	2	25	2	29	3

The cross tabulation shown in Tables 6 deals with how much the percentage is that a family member influences when any one of the family members is employed in engineering-related areas. The survey questions that were used to develop Table 5 were also used to develop Table 6. The result shows that when the father was employed in engineering, his influence was 36 percent for the progeny to choose engineering; the mother's influence was 18 percent, a brother's was 7 percent, a sister's was 7 percent, an uncle's was 11 percent, an aunt's was 5 percent, a grandfather's was 8 percent, and a grandmother's was 7 percent. However,, when an uncle was employed in engineering, his influence factor on the nephew or niece was 15 percent, whereas the father's influence factor on the progeny was 24 percent. Similarly, when a grandfather was employed in engineering, his influence on the child was 19 percent. Overall, a father's influence was much larger when either the uncle or the grandfather was employed in an engineering-related area. The conclusion is that the father has greater influence on the progeny even though other family members were employed in an engineering-related area.

Table 6. Cross tabulation of employment in engineering vs. influence percentage of family members to choose engineering.

Employment in engineering	Influence percentage							
	Father	Mother	Brother	Sister	Uncle	Aunt	Grandfather	Grandmother
Father	36	18	7	7	11	5	8	7
Mother	29	37	3	3	11	3	11	5
Brother	28	15	18	8	8	5	10	10
Sister	36	21	7	14	7	7	0	7
Uncle	24	17	9	6	15	7	12	8
Aunt	23	16	7	7	14	18	14	2
Grandfather	21	16	5	7	14	8	19	9
Grandmother	25	17	8	8	8	8	8	17

The descriptive statistics of the students' interests and the academic performances in mathematics and physical science are shown in Table 7. The students self-reported their interest and performance using a five-point Likert scale, with "5" being "Strongly Agree" and "1" being "Strongly Disagree" in terms of interest measurement, and "4" being "Mostly A" and "1.5" being "Mostly less than C" in terms of performance measurement.

Table 7. CATA students' interests and their academic performance.

		Number	Minimum reported value	Maximum reported value	Mean	Std. Deviation
Mathematics	Interest	245	1.0	5.0	3.612	1.031
	Academic performance	245	1.5	4.0	3.011	0.663
Physical Science	Interest	238	1.0	5.0	3.501	1.113
	Academic performance	238	1.5	4.0	3.102	0.655

Bivariate analysis using Spearman's rank correlation coefficient method was performed to find the relationship between interest and academic performance. The results shown in Table 8 reflect that there is a strong association between the student's academic performance achieved in a subject and their interest in it. The results are significant at 0.01 significance levels.

Table 8. Correlation between interest and academic performance.

	Number (n)	Spearman's rank correlation coefficient (ρ)	Significance coefficient	Significance level (2-tailed)
Mathematics	245	0.411	< 0.005	0.01
Physical Science	238	0.337	< 0.005	0.01

Discussion

The secondary data used in this research is non-parametric data. Therefore, it is not possible to perform a common parametric statistical analysis that would prove the hypotheses at a given

significance level. Therefore, the proof of the hypotheses is based on face validity provided by percentages of sample.

The first hypothesis was to determine if there is a positive association between a student's enrollment in an engineering curricula and the employment of at least one family member in engineering industry. Results of the analysis shown in Table 9 shows that 59 percent of the students who choose engineering had at least one family member employed in an engineering-related area. When analyzing the CATA student's intent to pursue an engineering baccalaureate and the employment of at least one family member in engineering, more that 50 percent of the students' responses indicated that they had one or more family members who were involved in engineering. This further proves that the family role is a significant influence in career choice.[12]

Table 9. Relationship between students and their family member employment.

	Number of students responded	At least one family member involved in engineering (%)
Students enrolled in high school engineering curricula	288	59
Students intend to pursue an engineering baccalaureate	255	53

The data were analyzed and the relationship identified between CATA students enrolled in a engineering curricula and their intent to pursue a baccalaureate. The results are shown in Table 10. The results reveal that students in CATA engineering curricula are more likely to pursue an engineering baccalaureate than an architecture-related or construction-related baccalaureate. Eighty-one percent of the students intended to pursue their baccalaureate in engineering. The result supports the third hypothesis that students who were enrolled in the high-school pre-engineering curricula plan to pursue an engineering baccalaureate.

Table 10. Student's curricula and intent to pursue a baccalaureate.

Student's study area	Respondents	Area of first priority to pursue a baccalaureate	First priority (%)
Engineering (288)	255	Architecture-related	13
		Construction-related	5
		Engineering-related	81
		Other	1

The CATA students provided information regarding their beliefs about post-baccalaureate employment in engineering. The results are shown in Figure 5. The objective was to determine if their beliefs influenced their consideration to pursue an engineering baccalaureate. From their responses, it can be inferred that they were not going to pursue an engineering baccalaureate based upon the assumption that employment would be easy to obtain just by earning a baccalaureate. Sixty-two percent of the respondents who indicated that they wanted to pursue an engineering baccalaureate supported this conclusion. This indicates the weak association between interest in pursuing an engineering baccalaureate and post-baccalaureate employment in engineering.

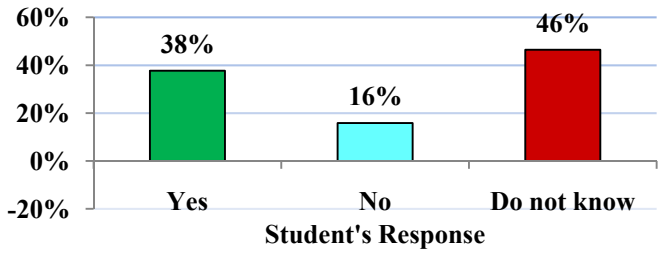

Figure 5. Student response on whether they believed that they having an engineering baccalaureate will help them gain employment as an engineer.

From the data presented in Figure 3, 36 percent of the students enrolled in a CATA engineering curricula and 27 percent of students enrolled in other CATA curricula selected engineering disciplines that are not offered in Nevada universities. These engineering disciplines are architectural, aeronautical/aerospace, agricultural, biomedical, chemical, construction, environmental, industrial, materials, and nuclear. From the data collected, it is not possible to determine if the student selections were informed choices or whether they were uninformed choices. While Nevada universities do not offer these baccalaureate disciplines per se , the University of Nevada, Las Vegas (UNLV) and the University of Nevada, Reno (UNR) do offer concentration areas in civil and mechanical engineering that closely correspond to some of the disciplines; as a result, students can learn the basics in Nevada. Also, it is also not possible to determine from the data if the students selecting the disciplines not offered in Nevada planned to attend a university in another state offering the discipline.

Table 11 presents where CATA students plan to pursue an engineering baccalaureate. The students who are enrolled in a CATA engineering curricula are approximately equal in number regarding whether they plan to attend a Nevada university or an out-of-state university.

Table 11. Where CATA students plan to pursue an engineering baccalaureate.

Where Students Plan to Pursue an Engineering Baccalaureate	Students Enrolled in CATA Engineering Curricula	Students Enrolled in CATA Non-Engineering Curricula
Nevada Universities	38%	42%
- University of Nevada, Las Vegas	26%	32%
- University of Nevada, Reno	12%	10%
Out of State Universities	37%	21%
Undecided	22%	25%

The students who are enrolled in a CATA non-engineering curricula and plan to pursue an engineering baccalaureate are twice as likely to indicate a Nevada university as their preference over an out-of-state university. However, at 21 percent, selection of an out-of-state university by the CATA non-engineering curricula students is still very high. CATA students pursuing non-engineering curricula are four times more likely to plan to attend a community college and transfer to a university than the CATA engineering curricula students. The results regarding the number of students indicating that they plan to seek an engineering education at an out-of-state university should be of concern to those in Nevada's higher education system.

Conclusions

Enrollment in the CCSD CATA engineering is very male dominated, at 74 percent. This supports the previous research findings that although women make up more than 50 percent of the U.S. population, they are significantly underrepresented in Science, Technology, Engineering, and Mathematics (STEM) fields.[13] A national study of freshmen found that women of all racial/ethnic groups were less likely than men to choose to study science and engineering. [14] Previous research findings conclude that the influence of parents and teachers is critical for STEM career decisions.[15] A strong sense of self-efficacy, especially for women students who are under-represented in engineering classrooms, can help them persist and enable them to become practicing engineers.[16] Efforts need to be increased and strengthened to recruit female students.

The analysis revealed that when a family member is employed in a engineering-related industry, the likelihood that a student would enroll in a CATA engineering curricula increases. The results supported the first research hypothesis that a student whose parents or family members are employed or have been employed in an engineering related industry are more likely to be enrolled in engineering as an area of study in high school. This study did not investigate whether a parent or the student was ultimately responsible for making the decision on what course of study the student would enroll in a CATA.

As observed in Table 3, 49 percent of the students enrolled in the CATA engineering curricula had fathers who were employed or had been employed in engineering-related work. This indicates that there may be a causal relationship between a father's employment in engineering-related work and the progeny's decision to pursue education in engineering curricula at a CATA.

Table 4 shows that many of the students could potentially be first-generation college graduates. Forty-four percent of the fathers, 33 percent of the mothers, 62 percent of the brothers, and 56 percent of the sisters did not obtain any education beyond high school. From the data collected, a disturbing trend appears to be emerging that fewer children are going on to post-secondary education than their parents.

When family members are employed in an engineering-related area, there is a greater likelihood that their children will pursue a baccalaureate degree similar to the field in which their parents are employed. In this research, 59 percent of the students indicated that they had one or more family members who were involved in engineering. Thus, the second research hypothesis is positively supported that students whose parents or family members are employed in or have been employed in an engineering related industry are more likely to plan to pursue an engineering baccalaureate.

Eighty-one percent of the students enrolled in a CATA engineering curricula indicated as their first priority an engineering-related discipline for their baccalaureate study. This result was supportive to the third hypothesis, that a stronger degree of students planning to pursue baccalaureate study in a engineering-related area was expected from students already enrolled in a high school engineering curriculum.

Another research finding is that only 38 percent of the responses showed students believed that employment is easy to obtain after earning a baccalaureate in engineering. This validates the fourth research hypothesis that the interest in pursuing a baccalaureate in engineering is independent of the student's belief that employment is easily obtained in this sector. The findings of this research are in accordance with the findings of previous studies, which state that the students are more connected to the performance-oriented aspects of careers than monetary remuneration. [17]

Research Limitation

The research is based on student responses from four Clark County School District (CCSD) Career and Technical Academies (CATA) students. The results may not represent other technical academies, comprehensive high schools or vocational high schools. More definitive results can be obtained if more high schools are surveyed and more geographical locations included.

Recommendation

Multivariate analysis is recommended to better understand the importance of the various factors driving student interest in enrollment in high school engineering curricula that is college preparatory in nature.

The data collected is very rich and offers significant opportunities for additional research analysis to study a variety of other topics of interest to engineering and high-school educators.

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