Polytechnic Students' Aspirations, Interests, and Confidence: Case Study on Students' Understanding of and Reasoning for Major Selection

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Abstract:
This case study explores the conceptions held by first year polytechnic students at Purdue Polytechnic New Albany related to technology majors. Specifically, this research examines how technology students define Mechanical Engineering Technology, Electrical Engineering Technology, and Computer Graphics Technology majors, their confidence in their given definitions, and the future job titles they associate with technology majors. The data for the study was collected from survey responses of 34 polytechnic students in a fall 2016 gateway to technology course. Qualitative data (i.e. structured survey text) was analyzed using NVivo® to identify themes, trends and patterns in the students' responses. Quantitative data (i.e. scaled responses) was analyzed by common statistical software and methods (i.e. frequency, mean, standard deviation, etc.). Results of the study show that the primary factor cited by students in choosing a major was interest in the discipline-specific subject matter. It was also found that most students associate technology majors with the process of design. These findings can be used by technology programs to re-design recruitment efforts in a manner that addresses the uncertainty and misconceptions held by incoming students. Thus helping them to better align their aspirations and interests for the future with an academic major.

Introduction:
In response to documented demand for engineering and technology graduates [1], a variety of studies have been conducted with the aim of better understanding why students choose to enroll in specific engineering programs. Most of these efforts have looked at the motivations of students already enrolled in engineering schools. A rich understanding of student motivation as it relates to their choice of college major has been established. One commonly held belief is that students choose to enroll in engineering and technology majors based on what they envision their career to be, a view supported by a variety of studies that have found evidence for behavior as a motivational construct for pursuing engineering (i.e. that students choose engineering and technology majors because they want careers where they build things, fix things, and solve problems). For example, Watson et al (2015) found that among first year civil engineers a drive to make/build things, the desire to be technically challenged, and a general interest in the field were the top three reasons cited by the students (among 10) for choosing engineering [5]. Other reasons students give for choosing engineering majors include an aptitude and enjoyment of science and math [2], [3] and high starting salaries [2].

However, in investigating methods to improve enrollment rates, it may be more instructive to look at reasons students chose either not to enroll in or to leave an engineering major. The majority of research in this area points to a general lack of understanding of engineering as a career. A community college research program designed to increase enrollment at Arizona State University found that "Not Interesting" and "Not Aware of Job Opportunities" were among the top three reasons given when non-engineers who participated in an outreach program were asked to indicate the factors as to why they did not choose engineering [2]. Similarly, a study of engineering persisters (those who graduated from engineering schools) versus switchers (students who changed degree to non-engineering) showed that both groups had a fairly limited knowledge of the profession and any knowledge had was almost entirely based on engineers they

knew personally or exposure gained through high school coursework, summer camps, and competitions. To address this shortcoming, the authors make the recommendation that programs need to be developed to educate K-12 students about engineering professions [4]. Similar results have been reported by Matusovich et al, who have found that even after four years in engineering school, 30% of students remain unsure of what it means to be an engineer [3], and recommend that a successful method to improve student enrollment is to "…help students understand what it means to be an engineer not only by teaching a variety of engineering skills, but also by exemplifying the breadth of activities engineers perform in their daily work….We need to make sure students do not develop a narrow view of engineering that omits activities and goals that might particularly interest them as individuals" [6].

The argument made in the cited research is that more students can be attracted to engineering if they better understand exactly what it is that professional engineers do. However, few, if any, studies have assessed the accuracy of students' pre-conceived conceptions of what it means to be an engineer or what engineers do as careers. As such, additional research is needed into the characterization of engineering and technology majors by freshman students. This study examines student conceptions of engineering technology majors and technology careers. The objectives were: (1) identify the dominant topics used by freshman technology students to describe Mechanical Engineering Technology (MET), Electrical Engineering Technology (EET), and Computer Graphics Technology (CGT) majors, (2) compare the conceptions of technology major programs between freshman students enrolled in different majors, and (3) identify job titles that freshman students commonly associate with MET, EET, and CGT majors. The results of the study are being used to help refine recruiting efforts so that they better explain technology majors to potential students in a manner that addresses common misconceptions and to identify methods by which current students can be better directed to majors that are in alignment with their interests and career goals.

Methodology:

This cross-sectional case study was conducted in the fall semester of the 2016-2017 academic year when a survey was developed by the authors and administered to technology students at Purdue Polytechnic. The survey instrument developed for this case study (Appendix 1) utilizes a mixed method format to collect both quantitative classification data and qualitative response data. The survey consists of three sections: (1) demographic and academic classification data, (2) aspirations and interest, and (3) definitions and confidence in technology majors. Section two asks respondents to identify why they chose their major, to select from a list of themes one that best identifies their aspirations related to technology careers, and to write their expected job title in their first employment after graduation. Section three asks respondents to provide open ended descriptions of the MET, EET, and CGT majors and to rate their confidence in their own description on a Likert-like scale.

Participants in the case study were taken from a convenience sample of MET, EET, CGT, Organizational Leadership (OL), Engineering Technology (ET), and Supply Chain Management (SCM) students enrolled in TECH120 Design Thinking in Technology at Purdue Polytechnic University, a Polytechnic technology program defined as:

> *Academic programs that combine theory-based applied learning, team-based projects, integrated humanities and social science studies, competency-based*

> *credentialing, and a series of experiential components such as industry-sponsored senior capstone projects, internships, global immersions, and certification-earning activities. The Purdue Polytechnic learning experience is designed to produce graduates who not only have deep technical knowledge and applied skills in their chosen discipline, but also possess problem-solving, critical thinking, communications, and leadership skills sought by industries and communities.*

TECH120 was chosen to implement the case study because it serves as a gateway to technology course for all Purdue majors, and is typically taken by students during their first semester. The paper-based survey was distributed by the researcher during the first meeting of TECH120 via collaboration with the course instructor. This timing enabled the researchers to access students representing all majors and to survey them prior to further exposure on their understanding of and opinions related to technology majors.

The completed paper surveys were transcribed into an Excel database and formatted for analysis using NVivo®, a qualitative data analysis software package for text-based data. The qualitative data from the survey was analyzed via word frequency analysis for the three to five most commonly used words (i.e. finding the frequency and context of words and phrases used by students in their responses). Textual data was analyzed for words greater than three characters in length, and grouped to include synonyms. For example, the frequency for the word "talk" included stemmed words such as "talking" and synonyms such as "speak". Results not providing insight into the research questions were manually removed from the word frequency search via a stop-words-list. The frequency data was then analyzed using tree maps and word trees. Tree maps show hierarchical data as a set of nested rectangles where the size of the rectangle indicates relative frequency of the word or phrase. Word trees display data as a tree with branches that represent the various contexts in which the word or phrase occurs. These visualizations were used to expose patterns and make comparisons between the student populations. Quantitative data was analyzed using histograms.

Aspirations and Interests
Surveys were first binned by major. The previously described word frequency and histogram analysis methods were then applied to the data.

Definitions and Confidence in Technology Majors
Surveys were first binned into one of two categories: in major or not in major. For example, the surveys were separated into those submitted by CGT students, and those submitted by all other students. The previously described word frequency and histogram analysis methods were then applied to the data. This was repeated for EET and MET to make comparisons between in-group and out-of-group definitions and confidence responses.

Results and Discussion:
In all, 44 students were surveyed, with 34 meeting the study criteria of first semester student enrolled in a technology program. Respondents not meeting these criteria were removed from the data set. Of the 34 students surveyed in the study, 27 were male, six were female, and one identified as genderfluid. Regarding major, 17 (50%) students (50.0%) identified MET as their major, 11 (32.4%) CGT, 3 (8.8%) EET, 2 (5.9%) Undeclared, and 1 (2.9%) OL. Regarding age,

one respondent was aged 13-17 years, 30 were 18-25 years, one was 26-34 years, and two were 35-54 years.

Aspirations and Interests

The Aspirations and Interests portion of the survey contained two qualitative open-response questions and one categorical response. Figure 1 shows the five most commonly used words MET students used in response to “Why did you choose your major?” Results show that factors influencing student choice for MET were primarily interest (i.e. students want to become METs because they enjoy subject matter). This is supported by the high rankings of the terms: design, interest, and enjoyable. Additional factors include utility (i.e. that there are jobs available for MET graduates). The frequency of the word mechanical in context of these results was primarily a modifier (e.g. mechanical design).

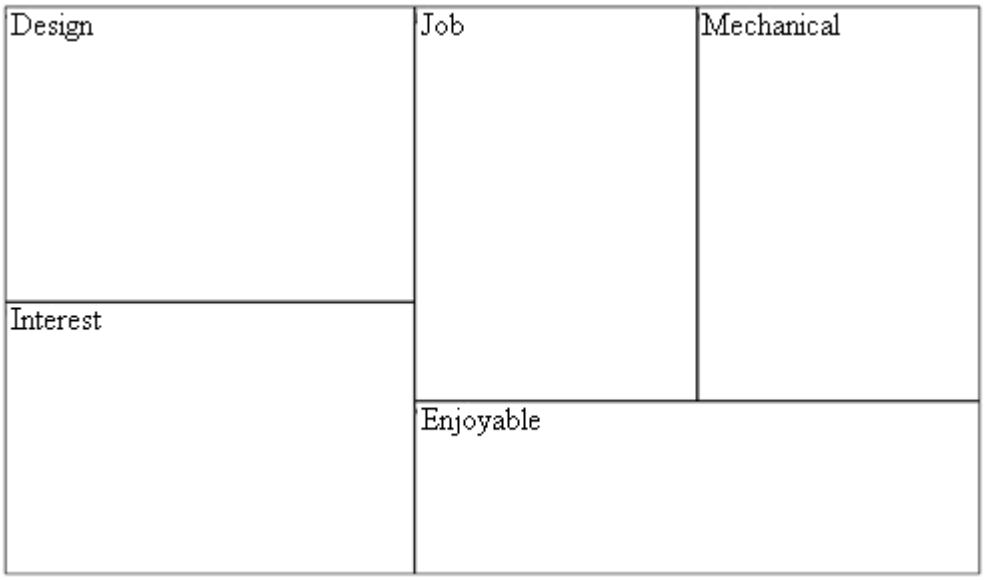

Figure 1. Tree map for MET student responses to "Why did you choose your major?”

Regarding the question to choose a reason regarding their motivations to become a technology student, MET student responses were: Cool Technologist = 14, Technology Entrepreneur = 2, and Social Activists = 1. The overwhelming score for Cool Technologist gives further support to the inference that MET students were primarily motivated by interest as the primary factor in selecting a college major. The job titles expected by the students were: “Unknown” = 9, “Mechanical Engineer” = 6, “Troubleshooter: = 1, and “Inventor” =1.

Figure 2 shows the five most commonly used words EET students used in response to “Why did you choose your major?” Results show that factors influencing student choice for EET were primarily interest. This is supported by the high frequency of the terms: computer, interested, enjoy. Additional factors include identification (i.e. that the student can see themselves in a career because of prior exposure to the field through personal relationships or experience). This is supported via the high frequency of the terms “dad” and “electrician”.

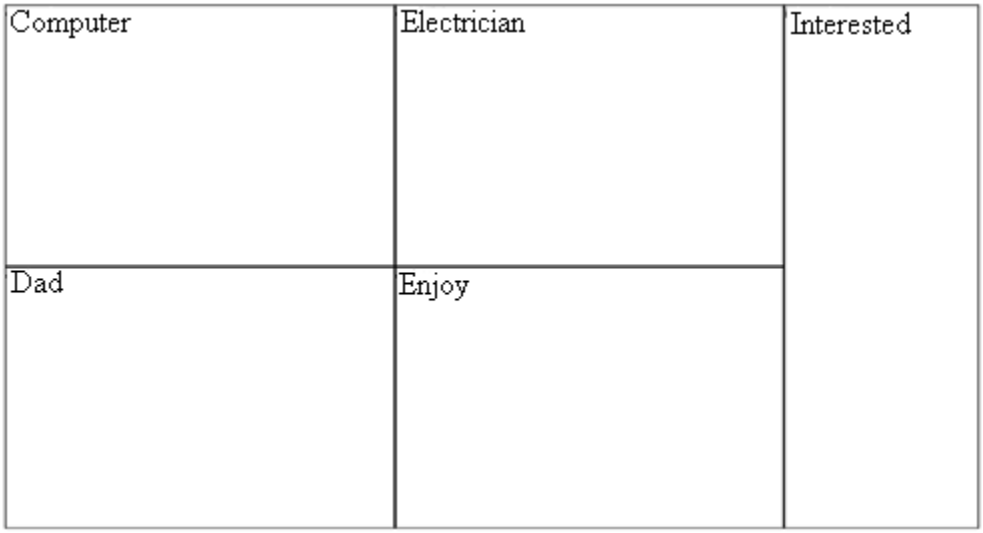

Figure 2. Tree map for EET student responses to "Why did you choose your major?"

Regarding the question to choose a reason regarding their motivations to become a technology student, EET student responses were: Other = 2 and Cool Technologist = 1. The job titles expected by the students were: "Unknown" = 2, "and "Electrical Engineer"= 1.

Figure 3 shows the five most commonly used words CGT students used in response to "Why did you choose your major?" Results show that factors influencing student choice for CGT were primarily interest. This is supported by the high rankings of the terms: design, cartoon, animation, and computer. The frequency of the word change was primarily related to utility (i.e. that the field is constantly changing and there will therefore be in demand).

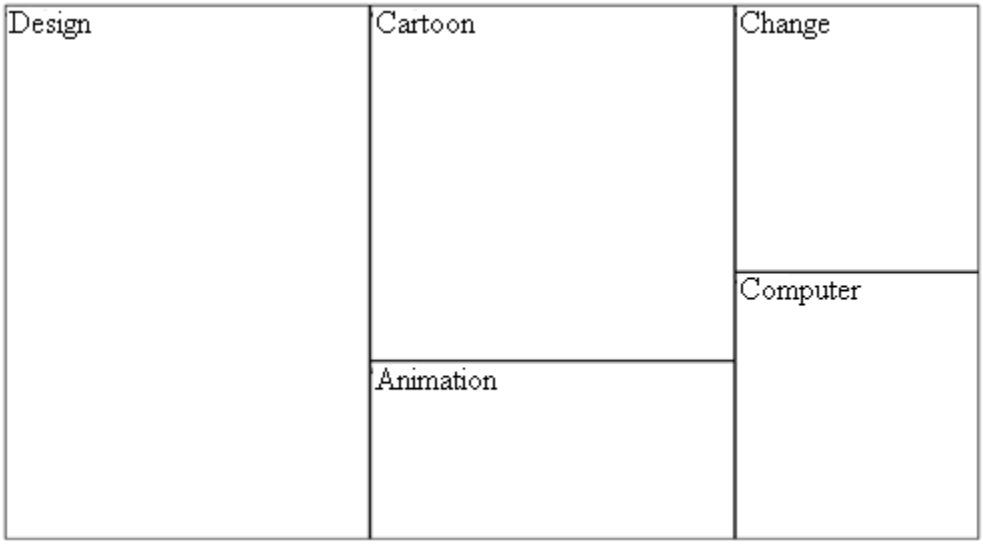

Figure 3. Tree map for CGT student responses to "Why did you choose your major?"

Regarding the question to choose a reason regarding their motivations to become a technology student, CGT student responses were: Cool Technologist = 6, Social Activist = 2, Other = 2, and Technology Entrepreneur =1. The job titles expected by the students were: "Unknown" = 3, "Web Designer" = 3, "Animator" = 2, "Graphic Designer" = 2

Taken together, these results overwhelmingly support the conclusion that the surveyed students chose their majors based on their personal interest in the subject. These results are notable in that none of the respondents of the survey indicated that they had an affinity for or self-efficacy for science and mathematics, a motivation that is commonly reported in similar studies [6],[7].

Definitions and Confidence in Technology Majors

The Definitions and Confidence in Technology Majors section of the survey contained four open ended response items and four related quantitative response items. Figure 4 compares the response of MET students only to the response of all other students when asked to define the major Mechanical Engineering Technology. Comparison of the tree map reveals that while the descriptions are overall consistently related to the construction of physical/mechanical devices, the responses of MET students focused more on the process of design, while non-METs focuses on physical construction.

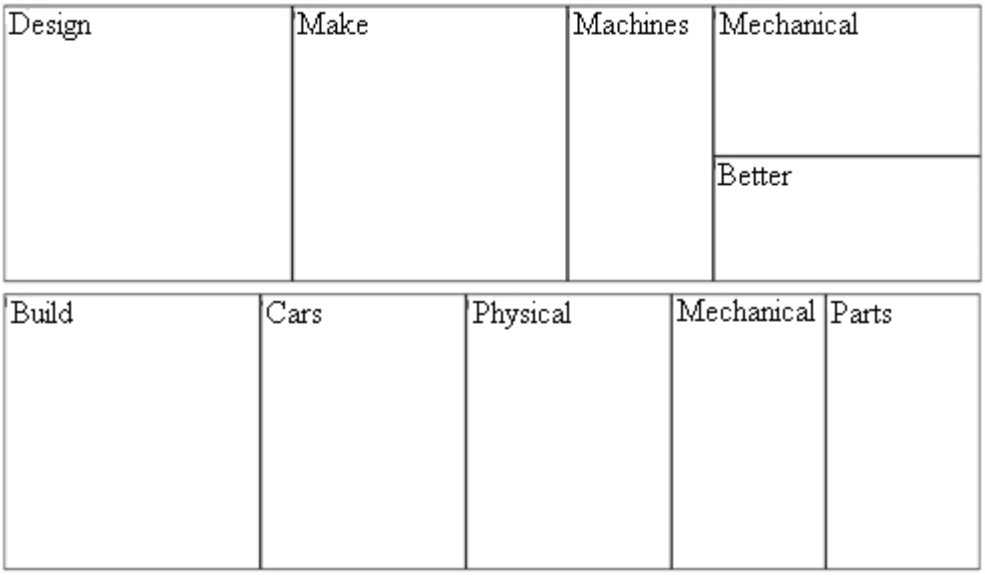

Figure 4. Tree map for "description of MET", MET Students on top, all others on bottom.

The most frequently occurring response from MET students was further investigated with a word tree to better understand the context of "design" among the responses. Figure 5 shows that, most commonly, students enrolled in MET consider the major to be associated with a formal process by which machines and parts are designed.

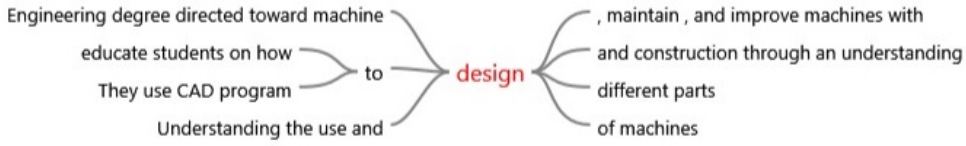

Figure 5. Word tree for MET student descriptions of MET major related to keyword "Design".

Figure 6 shows the confidence in the students in their responses when asked to define the MET major. Comparison between the two populations reveals that, overall, MET students report a much higher level of confidence in their given definitions than compared to all other students.

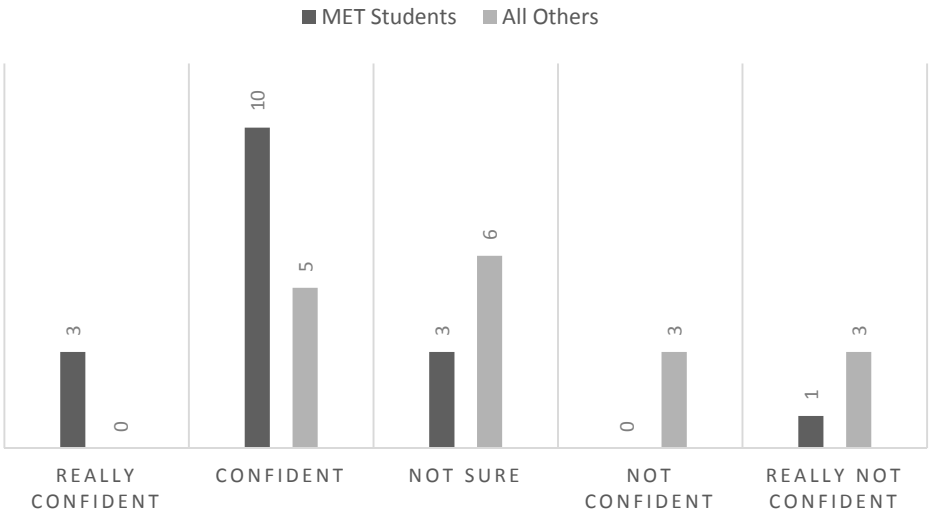

Figure 6. Comparison of reported confidence levels of students for describing the MET major.

Figure 7 compares the response of EET students only to the response of all other students when asked to define the major Electrical Engineering Technology. Comparison of the tree map reveals the descriptions to be consistent between sample populations. However, it is notable that non-EET students did not identify programming as part of their definition for EET.

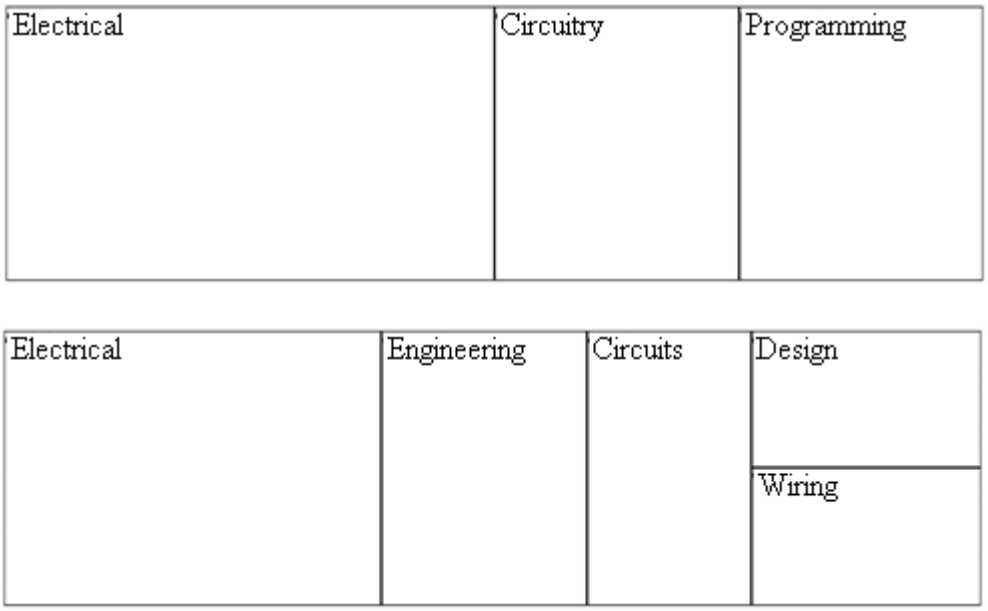

Figure 7. Tree map for "description of EET", EET students on top, all others on bottom.

The most frequently occurring response from EET students was further investigated with a word tree to better understand the context of “electrical” among the responses. Figure 8 shows that, most commonly, students enrolled in EET consider the major to be related to electrical systems and programming.

Figure 8. Word tree for EET student descriptions of EET major related to keyword "Electrical".

Figure 9 shows the confidence of the students in their responses when asked to define the EET major. Comparison between the two populations reveals that, overall, EET students report a high level of confidence in their given definitions. Additionally, it is notable that the majority of non-EET students reported "Not Sure" or below, indicating that many students do not feel that they understand "what EET is".

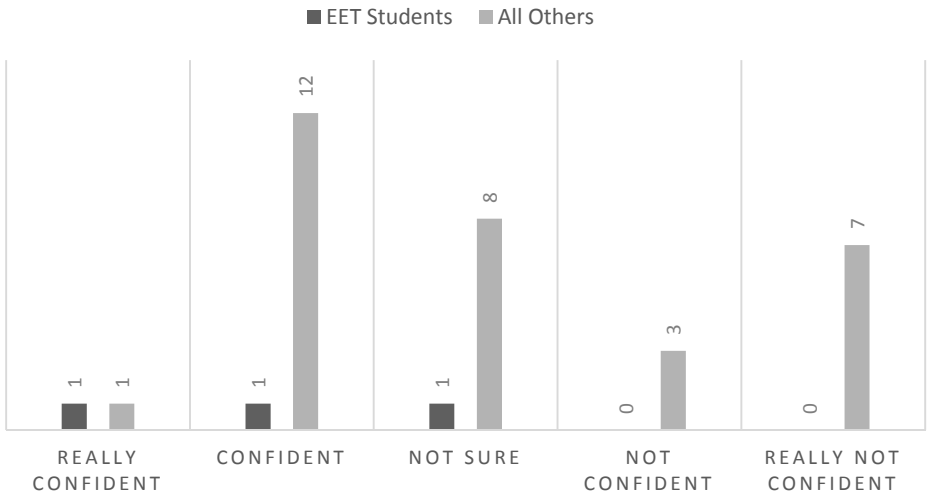

Figure 9. Comparison of reported confidence levels of students for describing the EET major.

Figure 10 compares the response of CGT students only to the response of all other students when asked to define the major Computer Graphics Technology. Comparison of the tree map reveals the descriptions to be consistent between sample populations.

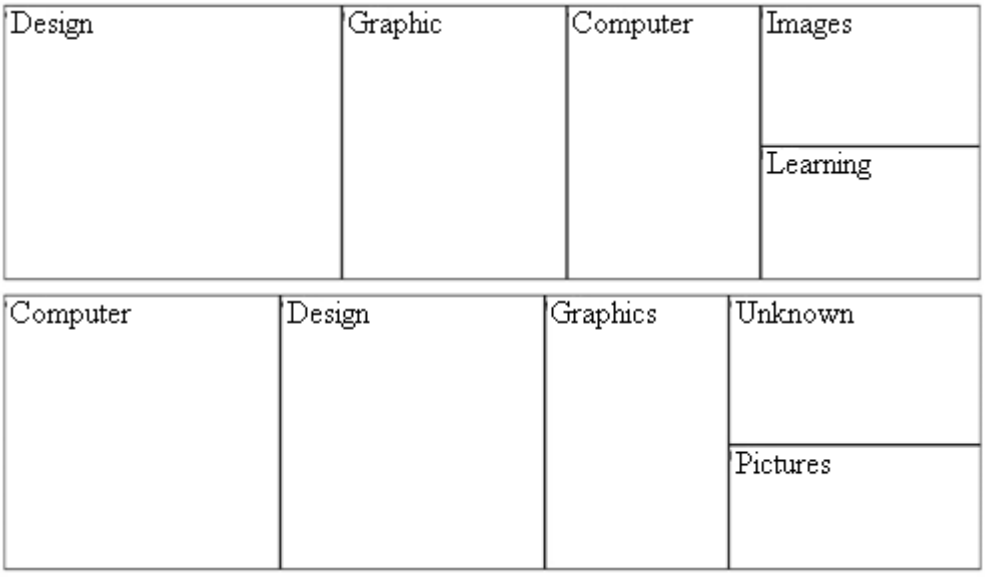

Figure 10. Tree map for "description of CGT", CGT Students on top, all others on bottom.

The most frequently occurring response from CGT students was further investigated with a word tree to better understand the context of "design" among the responses. Figure 11 shows that, most commonly, students enrolled in CGT consider the major to be related animation, web, and graphic design.

Figure 11. Word tree for CGT student descriptions of CGT major related to keyword "Design"

Figure 11 shows the confidence of the students in their responses when asked to define the CGT major. Comparison between the two populations reveals that, overall, CGT students report a high level of confidence in their given definitions, with slightly more non-CGTs reporting confidence in their response as non-confidence.

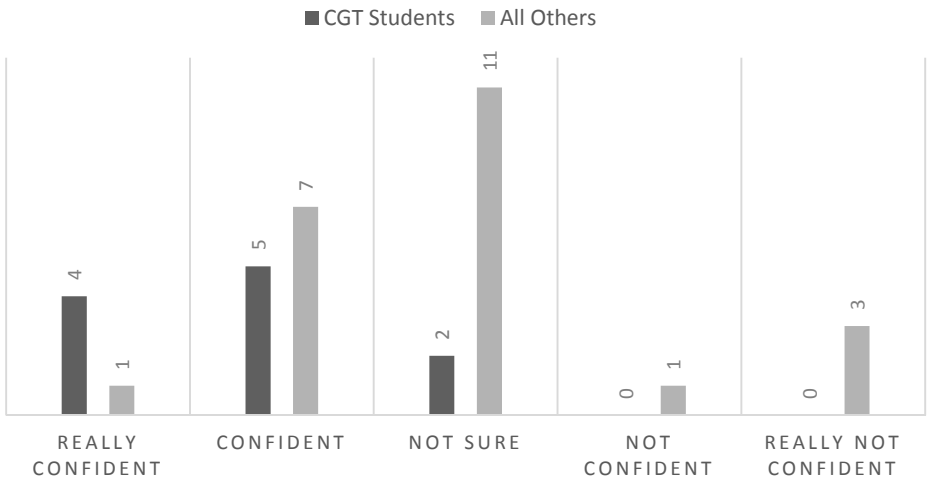

Figure 12. Comparison of reported confidence levels of students for describing the CGT major.

Conclusion and Future Work

This study explored the interests in and understanding of technology majors as held by first-year students enrolled at Purdue Polytechnic New Albany. Word frequency analysis of open-ended responses found that the primary factor cited by students in choosing a major was interest in the discipline-specific subject matter. This finding is supported by the result that "Cool Technologist" was the most common frequency aspiration given for reasons why technology was chosen as a major. Notably absent from these findings was any student input regarding the influence on math and science aptitude on choice of major. Word frequency analysis of open-ended responses also found that most students associate technology majors with the process of design, whether that may be mechanical, electrical, or graphical. This is in contrast to the often held association between technology program and maintenance engineers or technicians. An analysis of student confidence in their understanding of technology majors revealed that while most students are confident in their understanding of MET and CGT, many students express low confidence in their understanding of the EET major.

The authors see the implications of this study to be most useful in the design of recruitment strategies for incoming students. Since students choose majors based on their interests, recruiting efforts should be designed to show students the specifics of what they will do in a technology career. The data that this survey collected related to job titles reveals that simply listing job titles is not enough, as there is not a strong association between the job title and the actual tasks performed.

Because this survey was limited by the small sample size, particularly related to EET, future work will include expanding the survey to more students as they enroll in the TECH120 course. Additionally, the authors plan to collect longitudinal data. By re-surveying the same students at graduation, how their attitudes and definitions change over time can be better understood.

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Appendix 1

Q1. What is your gender?
- ❍ Male
- ❍ Female

Q2. How old are you?
- ❍ Under 13
- ❍ 13-17
- ❍ 18-25
- ❍ 26-34
- ❍ 35-54
- ❍ 55-64
- ❍ 65 or over

Q3. What is your current class standing?
- ❍ Freshman
- ❍ Sophomore
- ❍ Junior
- ❍ Senior
- ❍ Other/Unclassified

Q4. What is your current major?
- ❍ Mechanical Engineering Technology
- ❍ Electrical Engineering Technology
- ❍ Computer Graphics Technology
- ❍ Organizational Leadership
- ❍ Engineering Technology
- ❍ Supply Chain Management
- ❍ Other/Undeclared

Q5. Why did you choose your major? Please write legibly and write UNKNOWN on the line if you are unable to describe.

_____

_____

_____

_____

Q6. Take a few minutes and reflect on your aspirations and interests NOW and/or WHEN you decided to become an engineer. Then choose the most appropriate reason.
- ❍ Technology Entrepreneur: I inspire to be the next "Elon Musk, Bill Gates, Mark Zuckerburg, and/or Larry Page and Sergey Brin" "Start a Business"
- ❍ Social Entrepreneur/Activist: I want to take direct action with my engineering skills to help people "Save the World"
- ❍ Cool Technologist: I want to work on and be part of creating innovative technology "Build Something"
- ❍ Other

Q7. After graduating, what do you expect your first job title to be? Please write legibly and write UNKNOWN on the line if you are unable to provide.

_____

_____

Q8. In two to three sentences, please provide individual *descriptions* for the following majors and rate how *confident* you are with your given answer for each. Please write legibly and write UNKNOWN on the line if you are unable to describe.

a. Mechanical Engineering Technology:

_____

_____

Really Confident	Confident	Not Sure	Not Confident	Really Not Confident
❍	❍	❍	❍	❍

b. Electrical Engineering Technology:

_____

_____

Really Confident	Confident	Not Sure	Not Confident	Really Not Confident
❍	❍	❍	❍	❍

c. Computer Graphics Technology:

_____

_____

Really Confident	Confident	Not Sure	Not Confident	Really Not Confident
❍	❍	❍	❍	❍