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Specificity of Discipline as an Influence on Entry-Level Engineering Occupational Alignment*

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In this study, we explore how engineering specificity of discipline impacts occupational alignment of engineering graduates. Theoretically, we view this issue through the lens of the theory of occupational choice, as it relates to Social Cognitive Career Theory. The current state of research highlights the fact that many variables have been determined to influence engineering graduates' career decisions, though specificity of discipline has not been thoroughly explored as one of those variables. Empirically, historical National Survey of College Graduates data was examined for relationships and quantitative methods found a relationship between specificity of discipline and occupational alignment, with traditional engineering specificity having the most occupationally aligned graduates, followed closely by specific, and then general engineering.

Keywords: depth vs. breadth; occupational alignment; specificity of discipline; field retention

1. Introduction

When the Soviet Union successfully launched the world's first artificial satellite, the United States took the defeat as a challenge to increase the country's global technology and innovation presence [1]. Since the dawn of the space age, the U.S. has placed an emphasis on producing its own highly qualified science, technology, engineering, and mathematics (STEM) professionals, as evidenced by the dedication of entire federally-funded entities, such as the National Science Foundation, to the progress of science and engineering. Even legislative actions, like the STEM Education Coordination Act of 2009 [2] have been dedicated to the growth of the nation's STEM fields.

The 2020 United States National Science Foundation report on labor force indicates the need for engineers in the United States is estimated to increase by 8.2% between the years of 2016 and 2026 [3]. To supply the country with more qualified engineers, academic institutions are expected to increase the output of degreed engineers. Usually, this is where discussions of recruitment and student retention enter, but what if there is another variable to consider? What if the engineering students are recruited and retained, but engineering graduates are not choosing careers aligned with their field of study, and thus, not entering into the engineering profession after graduation? This issue would not be one of recruitment or retention, as the students persisted to obtain an engineering degree; they simply did not utilize their degree after obtaining it. In these instances, students have spent approximately four or more years at an academic institution investing in a particular program of study, but upon graduation have made the choice to pursue non-engineering career paths. This mismatch in entry-level occupational alignment to academic discipline is the focus for this study.

2. Background

2.1 Theoretical Framework

2.1.1 Occupational Choice

The conceptual framework of occupational choice began as a discussion of two types of factors – individual and occupational [4]. According to Blau et al. [5], these factors are inclusive of social experiences that shape personality development of potential workers and conditions of occupational opportunity that limit the realization of their choices. While these factors provided the beginning foundations for a theory, the authors stated that more empirical research was needed to facilitate a theoretical framework.

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From Blau et al.'s [5] conceptual basis, theoretical frameworks have since emerged. Super's [6] theory suggests that "self-concept" impacts occupational choice and Taylor [4] takes this theory two steps forward to include two additional features necessary to describe occupational choice. These features, describe by Taylor [4, p.42], are:

1. "Occupational choice is not a random phenomenon, but is, to a greater or lesser degree, purposive.
2. It is a central mechanism of the occupational choice process that an individual's preferences tend to become aligned with their future expectations.
3. Occupational choice can be seen as a compromise between an individual's preferences and the labour market constraints of the occupational structure."

From these features, occupational choice can be further evaluated for engineering graduates, specifically. Since the engineering occupation requires degreed applicants and obtaining an engineering degree involves purposeful steps, feature one from Taylor's framework is fulfilled for engineering occupations, and requires no further analysis. Feature three of Taylor's framework can be disregarded for this time and place in history, as the U.S. Bureau of Labor Statistics' Employment Projections report has identified occupational growth in all twenty acknowledged engineering disciplines, except nuclear engineering, which indicates that the labor market is in favor of most every type of engineering discipline [7]. This fulfillment of feature one and omission of feature three leaves feature two as an important area of study when applying Taylor's framework to engineering. Taylor's [4] second feature implies that career preferences become aligned with future expectations, while Super's [6] theory indicates that self-concept impacts occupational choice. As these two theories do not conflict, they might be considered complementary. The construct of self-concept is a broad one, as it encompasses perceptions of oneself reinforced by evaluative inferences [8]. This generalized construct includes the more specific construct of self-efficacy, which deals primarily with perceived cognitive capability within a given domain [9]. The construct of self-efficacy is a more ideal construct to evaluate, as Bandura states that self-concept combines too many attributes into a single index, and loses meaning if self-efficacy is not present [10]. Thus, the more precise construct of self-efficacy will replace self-concept in this analysis.

To understand how Taylor and Super's theories of preferences, expectations, and self-concept (or more specifically, self-efficacy) influence one another, social cognitive career theory (SCCT) paints an enlightening picture.

2.1.2 Social Cognitive Career Theory

To evaluate the impact preferences, self-efficacy, and outcome expectations impart on occupational choices, SCCT can be utilized. SCCT framework is based on Bandura's [11] general social cognitive theory, but emphasizes how individuals act with motivation and direction in their career development [12]. According to Lent and associates [13], the three concepts of self-efficacy, outcome expectations, and preferences (called "interests" in SCCT) are interrelated, as seen in Fig. 1, and impact major choice goals, or occupational choice. The relationships between the three variables are visible when structurally modeled, and can be described as each playing a role in achieving academic and career pursuits, though outcome expectations impact choice goals much less than the other two concepts. Lent and colleagues' [13] research describe each relationship in the figure by a lettered path:

Path (a) – Self-efficacy promotes favorable outcome expectations
Path (b) – Students tend to develop interests in academic subjects for which they possess strong self-efficacy
Path (c) – Students tend to develop interests in academic subjects for which they have positive outcome expectations
Paths (d), (e), and (f) – Intent to persist at a course of action (choice goals) results from self-efficacy, outcome expectations, and interests (paths d, e, and f, respectively).
Path (g) – Social supports positively impact goals
Path (h) – Barriers negatively impact goals
Paths (i) and (j) – Supports and barriers indirectly impact choice goals by improving or hindering self-efficacy

The SCCT structural model shows correlations between variables along each lettered path as well as the percentage of the response variable variation (R^2) explained by the model on each node. This model indicates that self-efficacy largely influences outcome expectations, interests, and major choice goals (occupational choice).

While SCCT presents a valid model for how students make their occupational choices, student career decisions have been viewed through numerous perspectives at differing levels of theory and application. A summary of the literature findings is presented in the following section.

2.2 Current State of Research

Literature guiding the previously described theoretical framework manifests a plethora of additional

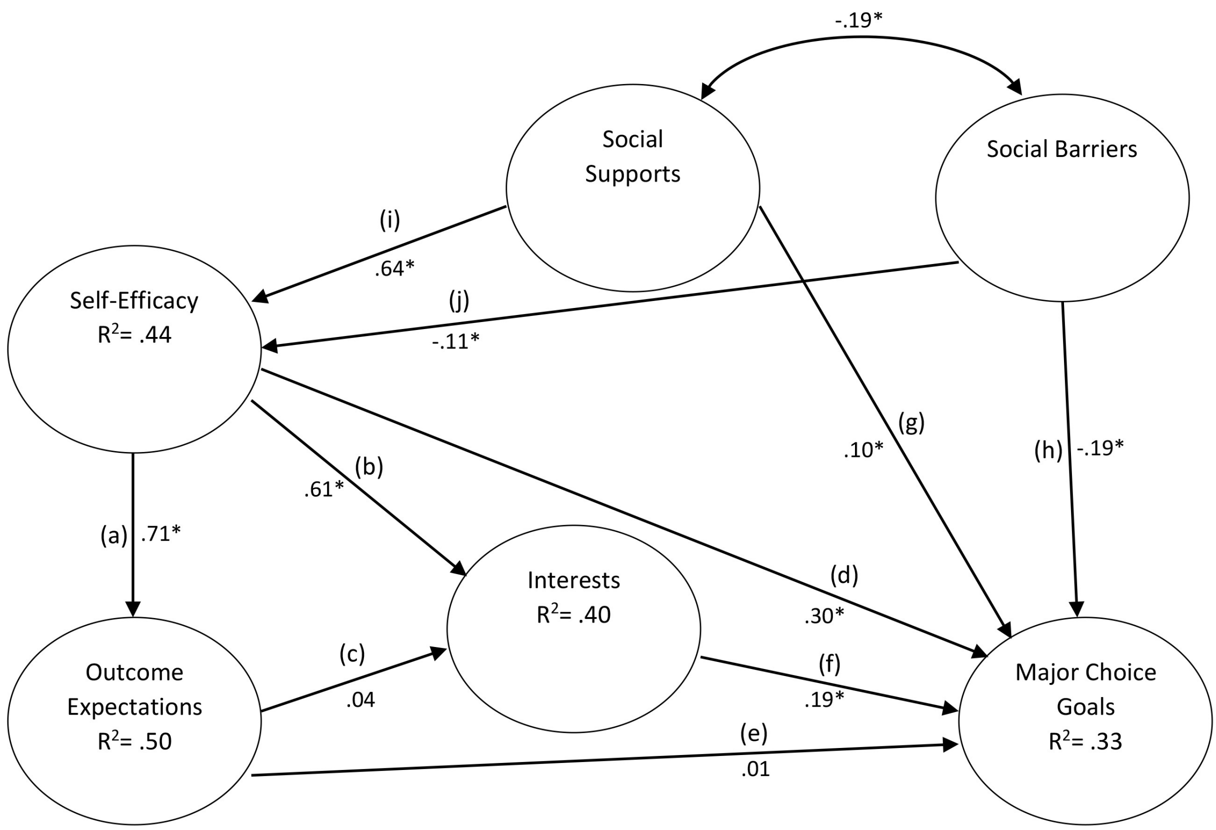

Fig. 1. Social Cognitive Career Theory Structural Model * $p < 0.05$ [13].

variables influencing engineering graduates' career decisions. After conducting a literature search, the current state of research investigating engineering occupational choice and alignment to academic discipline is described below.

Many questions regarding retention of engineering students to graduation have been answered, but not as many studies have focused on the retention of engineering students in the field of engineering *after* graduation. Of the studies conducted in relation to engineering occupational choice, many focus on the characteristics and traits of the person choosing, rather than the content of choice [14]. Work by both Roe [15] and Holland [16] describe matching particular personality traits to occupational categories as a means of occupational choice. Studies of occupational choice viewed through cultural, psychological, and sociological lenses are more prevalent than those questioning the role of engineering education in defining an engineering student's career path. However, researchers are looking at how educational *experiences* impact occupational choice. Korte and Smith [17] argue that poor learning environments constructed by engineering programs negatively affect students' values about the profession of engineering, and influence their decisions to leave engineering.

One study by McDonough and Wagstaff [18] focused on the content of choice instead of the traits of the choosing individual. This study evaluated the perceptions of 16- to 18-year-old students in regard to degree relativity (how closely the occupation pursued after graduation is related to the degree), utility (how useful the degree would be for obtaining employment), and the probability of employment in the field. Findings indicate that perceptions of utility (i.e. usefulness of the degree for obtaining employment) are significant predictors of obtaining employment in that field after graduation. Engineering degrees were found to be the second most useful degree (tied with computer science) of 16 options listed. This study sheds minimal light on if these perceptions correlate with actual choices of students after graduating with a degree, as the study surveyed students entering college, rather than exiting. The concept of the study, however, opens the door to exploration of how specificity of discipline impacts occupational alignment.

More recently, Ro [19] conducted work to include an investigation into the influence of precollege characteristics, academic program experiences, and student perceptions on post-graduation plans. This study discovered that compared to mechanical engineering, those who major in general engineering have greater odds of pursuing non-engineering careers [19]. Similarly, Sheppard and colleagues [20] found that civil and environmental engineering majors were more likely to have engineering-focused plans after graduation, as opposed to bio-x engineering majors.

Brunhaver [21] took a different approach and studied recent engineering graduates' self-described occupational titles and compared them to the graduates' perceptions of how related their position was to engineering. Brunhaver found those individuals reporting to work in an engineering position tended to perceive themselves as working in engineering and those who reported employment in non-engineering positions tended to perceive themselves as working in a non-engineering occupation [21]. This conclusion supports the supposition that engineers are normally rational in their situational perceptions. However, this study did not include the graduate's major as a variable of interest.

This incomplete picture of specificity of discipline impacting occupational alignment is the catalyst for the study at hand, which aims to reveal relationships between differing specificities of engineering disciplines and occupational alignment for engineering graduates.

3. Research Question

This study aims to build upon Ro's [19] investigation into post-graduation plans to answer the following research question:

Does undergraduate specificity of discipline influence engineering occupational alignment upon graduation?

3.1 Specificity of Discipline

For this study, three levels of discipline are examined. These levels, each deemed a "specificity of discipline", refer to the breadth of focus conveyed within the program of study.

1. *General engineering.* This is the broadest level considered. In this level of specificity, the focus is interdisciplinary, and students are expected to be able to apply knowledge of engineering to design experiments and solve problems.
2. *Traditional engineering.* This level of discipline is more specific than general engineering, as there is an applied focus in each discipline not found in a general engineering discipline. This level considers the more traditional engineering disciplines of mechanical, electrical, chemical, industrial, and civil engineering, due to their long-standing acceptance as engineering disciplines and their historical associations. Horikawa and Guo [22] assert that civil engineering is the oldest established engineering discipline, and defined traditional engineering as applied science and mathematics concerned with building structures, machines, numerous products, systems, and processes. The traditional engineering disciplines, according to Horikawa and Guo, included all the listed disciplines of this level, minus industrial engineering. However, industrial engineering is the engineering discipline concerned with systems and processes [23], so it seems logical to include this discipline, based on Horikawa and Guo's definition. Historically speaking, civil engineering dates back to early 18th century [22], while mechanical, electrical, chemical, and industrial engineering were born just before or during the Industrial Revolution of the 19th century [24]. Because of the historical association to industry of mechanical, electrical, chemical, and industrial engineering, these disciplines are appropriate to group together. Though not created in the 19th century, civil engineering is what some would describe as the "original engineering discipline", and fits into the traditional grouping, as well. Additionally, between 1966 and 2012, these five engineering disciplines were consistently awarded the most degrees per year, as indicated in the National Science Foundation's detailed statistical report, *Science and Engineering Degrees: 1966–2012* [25]. This longevity of consistency in awarded degrees indicates that these disciplines have been generally accepted as engineering disciplines. Combining these five engineering disciplines to create a grouping titled "traditional engineering" is based on their historical similarities and longevity of the degree programs.
3. *Specific engineering.* This level considers all engineering disciplines not considered in the "traditional engineering" or "general engineering" categories. These disciplines have been created through modification of the traditional engineering disciplines or through an identified gap in traditional engineering disciplines, and thus could be considered narrower in focus. This level includes engineering disciplines such as aerospace engineering, petroleum engineering, computer engineering, metallurgical engineering, and biomedical engineering.

4. Implications

If the United States is to address the growing engineering shortage [3], identifying engineering majors with high attrition levels upon graduation could be helpful in directing students to the engineering discipline specificity they feel aligns with their interests. This alignment to interests is a foundational concept of SCCT and may aid in retaining graduates in engineering careers. The findings of this study could be used to support the development of more personalized academic guidance for those engineering majors found to have higher levels of attrition from the field after graduation. This guidance could come in many forms, ranging from increased faculty involvement to program entry questionnaires, used much like the Armed Services Vocational Aptitude Battery (ASVAB) test. Since a potential reason for engineering graduates seeking employment in a field other than their degree may be due to a misalignment between student interests and degree choice, an ASVAB-like test may assist in identifying domain strengths and interests of entering undergraduate engineering students for placement into a major.

5. Methods

Quantitative research methods were used to analyze historical data. The purpose of analyzing survey response data was to determine how the independent variable, specificity of discipline, impacts the dependent variable, occupational alignment.

5.1 Data Source

The National Survey of College Graduates (NSCG) published by the National Center for Science and Engineering Statistics (NCSES) was utilized. The United States Census Bureau is responsible for administering the survey under National Science Foundation guidance and sponsorship through web surveys, mail surveys, and computer-assisted telephone interviews [26]. The data is available in a digital format biennially, and survey responses between 2010 and 2019 were used. The year selection intentionally omits participant responses for surveys conducted on or before 2008, as a survey design change occurred after the 2008 survey. Other than the larger design change after 2008, only small changes to survey questions have occurred throughout the years, such as occupation or education title adjustments to reflect more recent taxonomies and variable name adjustments.

5.2 Procedure

Survey response data from the NSCG was downloaded from the Scientists and Engineers Statistical Data System data download website (https://ncsesdata.nsf.gov/datadownload/). These files are available for public use as a Statistical Analysis Software (SAS) file, meant for use with the SAS statistical software suite. However, this file type can be converted into a Microsoft Excel file, and was converted for ease of data clean up.

5.2.1 Data Clean Up

Before analysis took place, the original data set was first decoded and cleaned. The major responses of interest and their NSCG descriptions are shown in Table 1. These responses were kept and combined for the 2010, 2013, 2015, 2017, and 2019 NSCG data sets. Only engineering majors having a bachelor's degree as their highest degree type were included, as to not address graduate school influences on occupation in this study. Also, returning participant responses were deleted, leaving only first-time participant responses.

Missing information was coded in the original data as "998", "9998", "9999998", or "Logical Skip". If the numerically-coded missing information was for a response of interest from Table 1, the entire participant response was omitted from the data.

5.3 Participants

Participant overlap exists from 2010 to 2019, as a major change in the design after the 2008 survey allows for participants, beginning in 2010, to com-

Table 1. Major Responses of Interest – Names and Descriptions for Decoding

NSCG data variable name	Description
Demographic/General	
GENDER	Gender
COHORT	Survey cohort
Education	
BSDGN	Number of bachelors or higher degrees
DGRDG	Highest degree type
NDGRMED (2010–2017)	Field of study for highest degree
N2DGRMED (2019 only)	Field of study for highest degree
Job variables	
OCEDRLP	Extent that principal job is related to highest degree
JOBSATIS	Job satisfaction
NRREA	Most important reason for working outside field of highest degree

plete a baseline survey and three biennial follow-up surveys [26]. Thus, survey participants can complete up to four surveys over approximately a six-year period. For this study survey data between 2010 and 2019 was used, and participant redundancy was removed. Only participants' first survey responses were analyzed, as relatedness of career choice upon graduation was of interest and first responses capture this information.

The target population for the NSCG includes individuals who meet the following criteria:

1. Earned a bachelor's degree or higher prior to January 1 of the year before the survey was administered.
2. Are United States residents younger than 76 years old as of February 1 of the year the survey was administered.
3. Are not institutionalized as of February 1 of the year the survey was administered.

After removing participant responses beyond their initial survey participation by utilizing the "COHORT" variable, 194,571 responses were available for analysis. Excluding participants who earned above a bachelor's degree yielded 100,896 responses. Finally, including only those participants who earned a bachelor's degree in an engineering discipline left 18,841 responses for analysis. The breakdown for demographics of interest for remaining participants is shown in Table 2.

5.4 Variables

The variable of interest, or dependent variable, was occupational alignment. This variable was denoted in the NSCG data as "OCEDRLP", which represents the responses to the survey question "To what extent was your work on your principal job related to your highest degree?". This variable contains three levels – not related, somewhat related, and closely related. The independent variable, specificity of discipline, was also analyzed at three levels. The discipline levels are general engineering, traditional engineering, and specific engineering. These levels were populated from decoding the NSCG data using the variable "NDGRMED" or "N2DGRMED" (for 2019 data), which was the field of study for participant degree (major). The "NDGRMED" and "N2DGRMED" survey responses were categorized based on the specificity of discipline guidelines established in the previous "Research Question" section.

Table 2. Participant Structure by Cohort and Gender

Cohort year	Gender		Total
	Male	Female	
2010	3,425	542	3,967
2013	4,444	758	5,202
2015	2,377	426	2,803
2017	2,440	483	2,923
2019	3,278	668	3,946
Total	15,964	2,877	18,841

5.4.1 Demographic Variables of Interest

Because women are less likely to have plans to enter engineering practice after graduation and are less likely to be retained in the field [27], gender was analyzed in this study. Cohort year was also examined to account for labor market variations over time.

5.5 Analysis

Statistical Package for Social Sciences (SPSS) software [28] was used for analysis after data clean up in Microsoft Excel [29]. Significance was tested using a chi-square test. If the calculated chi-square significance value was less than the chosen significance alpha level of .05, the variables were determined to be related (dependent). Analysis of the proportions was completed using crosstabulation with percentages for the levels of variables found to have a relationship. The percentages were used to evaluate the degree of relation between occupational alignment and specificity of degree.

6. Results

A total of 18,841 responses were analyzed to determine the extent that current job is related to degree earned. Responses were grouped based on specificity of the engineering degree earned by the respondent. The percentages of each occupational alignment response for each specificity of engineering degree are shown in Table 3.

The general engineering degree specificity had the lowest percentage of respondents in jobs closely related to their degree earned and the largest percentage of respondents in jobs not related to their degree earned. The opposite is true for the respondents earning traditional engineering degrees. Traditional engineering possessed the highest percentage of respondents in jobs closely related to their degrees and lowest percentage of respondents in jobs not related to their degrees.

A chi-square test of significance was used to determine the existence of any statistically significant relationships between specificity of discipline and occupational alignment. The null hypothesis of no statistically significant difference between specificity of disciplines for occupational alignment should be rejected, $\chi^2(4, N = 18{,}841) = 73.30$, $p < 0.001$. We can conclude that there exists a statisti-

Table 3. Occupational Alignment Proportions for Each Specificity of Discipline

Occupational alignment	Specificity of discipline			
	Specific engineering (N = 3,068)	Traditional engineering (N = 15,593)	General engineering (N = 180)	Total (N = 18,841)
Closely related	62.3% $_a$	65.9% $_b$	48.9% $_c$	65.1%
Somewhat related	27.2% $_a$	27.3% $_a$	37.8% $_b$	27.4%
Not related	10.5% $_a$	6.8% $_b$	13.3% $_a$	7.5%

Note: Each subscript letter denotes a subset of Specificity of Discipline whose column proportions do not differ significantly from each other at the 0.05 level.

cally significant relationship between specificity of discipline and occupational alignment.

The subscripts in Table 3 – a, b, and c – on the response count in each specificity indicate that SPSS found the column proportions to differ significantly from each other at the 0.05 level for each level of occupational alignment. Therefore, each occupational alignment level – closely, somewhat, and not related – is analyzed independently from the other levels using the pairwise analysis method with subscripts. As such, columns should be compared across columns, but not across rows. The "Closely Related" level encompasses 65.1% of the overall responses to the survey. The largest percentage at this level is seen in the traditional degree specificity. The "Somewhat Related" level includes 27.4% of the total responses, with general engineering specificity leading that level in responses, followed by both specific and traditional engineering specificities, as there is no statistically significant difference between the two at that level. The "Not Related" level held the smallest proportion of responses (7.5%). This level had more proportion contained in both the specific and general engineering specificities and less proportion in traditional engineering.

6.1 Analysis by Gender

The percentages were then analyzed by gender. The percentage reporting occupational alignment for both males $\chi^2(4, N = 15{,}964) = 54.00$, $p < 0.001$ and females $\chi^2(4, N = 2{,}877) = 13.37$, $p = 0.010$ differed by specificity of discipline. Out of the 18,841 responses, 2,877 were from females and 15,964 from males. Table 4 shows the post hoc analysis results.

At the "Closely Related" level females show no statistically significant difference between traditional and specific engineering, while males show differences between all three levels of specificity. At the "Somewhat Related" occupational alignment level, both genders show the same trend of general specificity having the largest percentage, followed by both specific and traditional engineering specificities, as there is no statistical difference between the two for both genders. At the "Not Related" level of occupational alignment, males have a statistical difference between both general and specific and traditional. General and specific engineering specificities both have larger proportions of "Not Related" occupational alignment than traditional engineering. For females, there is no statistically significant difference between general and specific and general and traditional engineering. However, there is a statistically significant difference between specific and traditional, with specific having a larger proportion of "Not related" responses than traditional engineering.

For both genders, the traditional engineering discipline had the highest proportion of "Closely Related" occupational alignment, either followed by or tied with specific engineering. General engineering had the lowest proportions of "Closely Related" responses for both genders.

6.2 Analysis by Cohort

Responses for all participants were analyzed by cohort year in order to look for corresponding trends with the job market and economic factors. Of the five cohort years analyzed, only 2017 possessed no statistically significant differences between specificity of discipline in relation to occupational alignment. All other cohort years studies found statistically significant relationships, as seen in Table 5.

Table 4. Occupational Alignment Proportion Relationships by Gender

Occupational alignment	Post-hoc comparison – significant differences	
	Male	Female
Closely related	Traditional > Specific > General	Traditional & Specific > General
Somewhat related	General > Specific & Traditional	General > Specific & Traditional
Not related	General & Specific > Traditional	Specific > Traditional (No difference between General and Specific or General and Traditional)

Table 5. Chi-Square Tests of Significance for Cohort Years

Cohort year	Pearson chi-square value	df	Asymptotic significance (2-sided)
2010	46.58	4	<0.001
2013	9.85	4	0.043
2015	19.67	4	0.001
2017	6.08	4	0.186
2019	18.51	4	0.001

Statistically significant differences in proportions were analyzed via crosstabulation post hoc analysis. Results from this analysis are displayed in Table 6.

As shown in Table 6, the highest percentage of "Closely Related" responses was reported by the traditional specificity group in three cohorts. For cohort year 2015, no statistically significant difference was found between specific and traditional engineering, but otherwise the traditional engineering discipline had the highest proportion for all years reporting statistically significant differences. At the "Somewhat Related" level, general engineering specificity had the highest proportion, though three years showed no statistically significant differences between specificities for this level. At the "Not Related" level of occupational alignment, specific engineering had the highest percentage of responses for the earliest three years, and general engineering had the largest proportion for cohort year 2019.

6.3 Analysis of Reasons for Working Outside of Field

Of the 18,841 usable survey responses, 1,414 (7.5%) reported that their job was not closely related to their degree field. Those participants were then asked to provide the most important reason for working outside their field of study from a standardized list of options, seen in Table 7. Across all specificities, "job in highest degree field not available", "pay or promotion opportunities", and "change in career or professional interests" were the most reported responses. For specific engineering specificity of discipline, approximately 25% of respondents indicated they were working outside of their field of study because a job in their field was not available. For general engineering, the same percentage reported working outside of their field for pay or promotion opportunities. Traditional engineering's most commonly reported reason for working outside of their degree field was due to a change in career or professional interest.

6.4 Analysis of Job Satisfaction

Job satisfaction was viewed across both levels of occupational alignment and specificity of discipline. The highest percentage of "Very Satisfied" responses was found in the "Closely Related" occupational alignment. The highest percentage of "Somewhat Satisfied" responses was found in the "Somewhat Related" occupational alignment. The

Table 6. Occupational Alignment Proportion Relationships by Cohort Year

Occupational alignment	Post-hoc comparison – significant differences				
	2010	2013	2015	2017	2019
Closely related	Traditional > Specific & General	None	Specific & Traditional > General	None	Traditional > General (No difference between Specific and Traditional or Specific and General)
Somewhat related	General > Specific & Traditional	None	General > Specific & Traditional	None	None
Not related	Specific > Traditional (No difference between General and Specific or General and Traditional)	Specific > Traditional (No difference between General and Specific or General and Traditional)	Specific > Traditional (No difference between General and Specific or General and Traditional)	None	General > Specific > Traditional

Table 7. Percentage of Each Specificity of Discipline Reporting Reasons for Working Outside of Field of Study

Reason for working outside of field of study	Specific engineering	Traditional engineering	General engineering	Total
Job in highest degree field not available	25.2%	19.8%	20.8%	21.0%
Pay, promotion opportunities	18.9%	19.9%	25.0%	19.8%
Change in career or professional interests	17.1%	20.6%	20.8%	19.8%
Family-related reasons	14.3%	11.0%	8.4%	11.7%
Working conditions	8.6%	10.8%	8.4%	10.3%
Other reason for not working	8.1%	9.5%	8.3%	9.1%
Job location	7.8%	8.4%	8.3%	8.3%

Table 8. Job Satisfaction across Occupational Alignment and Specificity of Discipline

Occupational alignment	Job satisfaction	Specificity of discipline			Total
		Specific engineering	Traditional engineering	General engineering	
Closely related	Very satisfied	48.0%	48.7%	46.6%	48.6%
	Somewhat satisfied	45.4%	45.1%	47.7%	45.2%
	Somewhat dissatisfied	5.2%	5.1%	5.7%	5.1%
	Very dissatisfied	1.4%	1.0%	0.0%	1.1%
Somewhat related	Very satisfied	35.3%	34.7%	41.2%	34.9%
	Somewhat satisfied	52.2%	53.1%	47.1%	52.9%
	Somewhat dissatisfied	10.5%	10.2%	10.3%	10.2%
	Very dissatisfied	1.9%	2.1%	1.5%	2.0%
Not related	Very satisfied	32.3%	27.9%	37.5%	29.1%
	Somewhat satisfied	44.7%	50.8%	41.7%	49.3%
	Somewhat dissatisfied	14.3%	15.0%	16.7%	14.9%
	Very dissatisfied	8.7%	6.3%	4.2%	6.8%

highest percentage of "Not Satisfied" responses was found in the "Not Related" occupational alignment. These observations can be seen in Table 8. Across specificities of discipline, traditional engineering leads in "Very Satisfied" job satisfaction scores, though by less than one percent. Specific engineering specificity has the highest percentage of "Very Dissatisfied" job satisfaction scores, which is found in the "Not Related" section of occupational alignment.

7. Discussion

Over 93% of respondents from the five degrees that make up the traditional specificity are reported working in jobs that were at least somewhat related to their degree, while almost 90% of specific engineers and 87% of general engineers reported working in occupations at least somewhat related to their degrees. These percentages indicate that the traditional specificity finds some level of occupational alignment most and general engineering specificity finds some level of occupational alignment least. At this overarching level, the practical implication for practitioners in the academic advising realm is to advise students into a traditional engineering specificity for the most probability of some level of occupational alignment. If engineering institutions want a *high* level of occupational alignment for their students after graduation, responses for "closely related" occupational alignment should be the variable of interest. Analysis of "closely related" responses show the same findings as the overarching level of analysis – Engineers with traditional engineering degrees are working in closely related jobs the highest proportion (65.9%) of all specificities. Engineers with general engineering degrees are working in the lowest percentage (48.9%) of closely related jobs. These results are consistent with the findings by Ro [19] which indicated that students majoring in general engineering have greater odds of pursuing non-engineering careers. A high percentage of specific engineering degree recipients (62.3%) reported working in jobs closely related to their field of study. However, this percentage is lower than traditional engineering degree recipients (65.9%). More specific does not lead to the most closely related jobs, necessarily. Traditional engineering degrees appear to be specific enough to be attractive to employers but also broad enough to provide a larger number of employment opportunities in related jobs. These findings are consistent with results from a previous study by Sheppard and colleagues [20] which found that the traditional engineering major was more likely to have an engineering-related plan after graduation than a more specific engineering major. Because traditional engineering disciplines have a longer history than some specific and general engineering disciplines, there may be a bias in industry toward traditional engineering specificities, making occupational alignment for the traditional specificity easier. This is further discussed in following sections, and could be the reason why general and specific engineering specificities report higher proportions of "not related" occupational alignment (13.3% and 10.5%, respectively) than the traditional specificity (6.8%).

7.1 Gender

The female respondents in this study represented only 15.3% of the total respondents. This small sample size supports the literature stating that women are less likely to plan to enter engineering careers and are less likely to be retained in the engineering profession [27]. The occupational alignment percentages across specificities showed that females find "closely related" occupational alignment in *both* specific and traditional specificities most, while males find "closely related" occupational alignment most in the traditional specificity alone. This difference may be due to survey response variations related to personal perception of occupational alignment. Since all data is self-reported in the NSCG, personal perceptions influence responses. However, if the data is taken at face-value, then these results indicate that females have more engineering discipline options available that potentially yield close occupational alignment. Conversely for females, the highest level of "not related" occupational alignment is also found in the specific specificity. Thus, recommendations for females to major in specific disciplines for the highest possibility of close occupational alignment may not be the best path, as specific disciplines lead in both the "closely related" and "not related" levels of occupational alignment for females. The traditional specificity may be a more reliable option for guiding both genders of students to occupational alignment after graduation.

7.2 Cohort

When the results were broken down by cohort, the proportions mostly mirrored the overall results for all the years. All but one of the years showed significantly different percentages between at least one of the specificities. Only one cohort year, 2017, showed no statistically significant relationship between occupational alignment and specificity of discipline. The traditional engineering specificity had the highest percentage of closely related jobs for all of the cohort years showing statistically significant relationships, followed by specific engineering degrees.

Economic recessions and variations in the number of job openings from year to year could cause engineering majors to enter into non-related jobs. This could explain the differences in proportions from year to year. The Bureau of Labor Statistics reported no recession and an increase in engineering jobs needed for the United States in 2017 [30], so those two reasons should not be considered for the non-significant relationship between occupational alignment and specificity of discipline for 2017. The reported job outlook for engineering and architecture positions between 2010 and 2020 saw a growth of 252,800 positions, or a 10.4% increase [31]. This growth included positive values in all but nuclear engineering [7], which falls within the specific engineering specificity, and may slightly attribute to differences between specific engineering specificity and the two other specificities, though nuclear engineering is a very small portion of the specific level of discipline. The most recent economic recessions documented by the Federal Reserve Bank [32] occurred between 2008 and 2009, and then more recently in 2020. These recessions are before and after the cohort years evaluated in this study, thus should not be a valid reason for differences between cohort years, except for cohort year 2010, which may have been impacted from the recession ending in 2009.

Based on the Bureau of Labor Statistics data [7], economic conditions and job availability seem to have equitably impacted all engineering disciplines, except for nuclear engineering. This may be the reason for similar trends shown in each year with statistically significant differences between depths of discipline. The one interesting difference that stands out is encompassed in the "not related" occupational alignment category. In 2019, general engineering took the lead over specific engineering for the largest proportion of "not related" occupational alignment. The reason for the takeover is unknown, but may relate to the changing industry and political climate of the nation at the time. The focus of the administration of that time focused more on increasing manufacturing in the country [33], which may lend itself to more traditional and specific depths, rather than the general engineering depth.

7.3 Reasons for Working Outside of Field of Study

Only 7.5%, or 1,414 participants, reported that their occupation did not align with their degree. Out of seven standardized choices, the top three reasons engineering graduates reported for working outside of their fields were:

1. A job in their degree field was not available (21.0%).
2. A change in career or professional interest (19.8%).
3. Pay or promotion opportunities (19.8%).

Of those individuals not working in their field of study, the most prominent reason for specific engineering disciplines to work outside of their field was due to a job in their field of study not being available. This connotates being forced outside of their field of study, rather than choosing to do so of their own desire. Academic advisors assisting in student major selection should be acutely aware that 10.5% of specific engineering graduates do not work in an occupation closely related to their degree, and of that percentage, about a quarter do so because an occupationally aligned job was unavailable.

Traditional engineering disciplines reported working outside of their field of study most because of a change in career or professional interests.

However, closely following this leading reason were the reasons of "pay, promotion opportunities" and "job in highest degree field not available". The less than one percent difference in response proportions for the three reasons indicates that traditional engineering graduates work outside of their field due to both positively and negatively associated reasons.

General engineering specificity participants reported pay or promotion opportunities as the most prominent reason for working outside of their degree field. While this response may seem like a positive reason, it could also indicate that more broad engineering jobs do not pay as well as engineering jobs aligning with more specific depths of discipline, thus driving general engineers to other career paths.

These reasons for working outside of their field of study give engineering institutions insight into obstacles their students may face after graduation. While engineering institutions may not be able to mitigate challenges to obtaining occupationally aligned jobs, they could impart this knowledge to incoming students, so students know their probabilities of occupational alignment and potential hurdles they face in obtaining such employment before they commit to a major.

7.4 Job Satisfaction

Job satisfaction seemed to correlate with occupational alignment, though not formally tested. "Closely Related" occupational alignment had the highest reporting of "Very Satisfied" job satisfaction, "Somewhat Related" had the highest reporting of "Somewhat Satisfied" job satisfaction, and "Not Related had the highest reporting of "both "Somewhat Dissatisfied and "Very Dissatisfied" job satisfaction. These findings indicate that occupational alignment and job satisfaction are positively related. Differences in job satisfaction between specificity of discipline were minimal. These results suggest that if engineering students want to be satisfied in their careers, they should strive to find a job that is aligned with their field of study, whatever specificity of discipline that might be.

7.5 Limitations

Analysis in this study was performed on self-reported survey data from respondents. *Perceived* self-efficacy can influence efforts and mobilization of resources [34], meaning that self-perception influences individual output – including survey responses. While respondents were asked to answer as accurately as possible, the survey results are based on respondents' *perceptions*, and individual perceptions do differ. Therefore, two participants choosing between "closely related" and "somewhat related" occupational alignment may perceive their current occupations as the same level of occupationally aligned, but may judge the two levels of alignment differently, based on their perceptions of what each option means, and thus choose different responses from one another.

A large number of respondents were analyzed, but the number of respondents in each of the engineering specificities should be noted. Out of the 18,841 responses analyzed, only 180 of them represented general engineering majors. That means that only 0.96 percent of respondents fell into the general engineering specificity of discipline. Though this approximately aligns with the overall percentage of general engineering degrees awarded across the United States, as only 1.55% of all engineering degrees awarded in 2019 were general engineering degrees [35], statistics generated from small sample sizes should be interpreted with caution, as smaller sample sizes could mean less accurate representation of the population they attempt to describe.

7.6 Future Work

Our study examines the number of engineering majors working in jobs related to their major at the time of the survey. Additional factors to be researched include the length of time engineering graduates work in an engineering field as well as career paths taken over the lifetime of an engineering career. Reasons for not pursuing an engineering major-related job at all after graduation could also be investigated. The most beneficial results may come from a deeper qualitative assessment, potentially in the form of interviews, that extract the reasons and circumstances surrounding occupational decisions. Additionally, comparison to other science, technology, engineering, and math graduates may find that occupational alignment for engineering graduates may not differ substantially from the other three branches of STEM. If this is true, the findings and recommendations of this study may be generalizable across all STEM degrees.

8. Conclusion

This study included analyzing data from the National Survey of College Graduates published by the National Center for Science and Engineering Statistics for a subset of 18,841 responses from engineering graduates. The purpose of the study was to identify any relationships between occupational alignment and specificity of discipline. Analysis included chi-square tests of significance as well as crosstabulations to compare proportions of responses. Ultimately, the study found that specificity of discipline does impact occupational alignment, however not in the linear, monotonic relationship expected. Traditional engineering is found to have the most occupationally aligned graduates, followed closely by specific, and then general engineering. Occupational alignment is of importance because job satisfaction seems to be positively correlated to occupational alignment. As alignment increases, so does job satisfaction. These results indicate that engineering institutions offering traditional engineering degrees prepare students for available employment positions that most align with their degrees. We recommend that engineering institutions continue to offer the five engineering majors that comprise traditional engineering, and any specific engineering majors to give students the best possibility for occupational alignment after graduation. General engineering majors should be offered with caution, as this major finds the least amount of occupational alignment.

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