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Engineering Student Perceptions of Their Generic Skills Competency: An Analysis of Differences Amongst Demographics

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Abstract

Assessment and accreditation are an important aspect in maintaining the integrity of engineering programs within higher education. Stakeholders of programs include students, faculty, and employers. Each stakeholder can provide their own perspective as to the assessment of the various skills that engineering programs boast to produce in their graduates. In particular, students strive to develop skills needed to be successful upon graduation within industry. The skills required to be assessed by ABET, one of the largest international accrediting organizations, are considered to be skills that can cross many disciplines and not necessarily isolated for one particular field. Bennet [1] refers to these skills as generic skills. Chan, Zhao, and Luk [2] indicates that these skills include academic and problem-solving skills, interpersonal skills, community and citizenship knowledge, leadership skills, professional effectiveness, information and communication literacy, critical thinking, and self-management skills. This study explored undergraduate engineering students' perceptions of their generic skills competency as it relates to individual demographics. Utilizing the Generic Skills Perception Questionnaire, 158 engineering students at a research university located in the Midwest responded to the survey providing feedback on their capabilities in the different generic skills. The survey found that women indicated higher levels of perceived competency in several of the generic soft skills than men. Additionally, the minority racial and ethnic students perceived themselves as more competent than their white peers for several of the generic skills, most of which are often considered to be soft skills. These findings have implications on research and practice in the engineering education of minorities in order to grow and build a stronger more diverse engineering workforce.

Introduction

Assessment and continuous improvement of student outcomes in contemporary engineering higher education programs are focal points in program-specific accreditation. ABET, one of the largest accreditors of engineering programs, has an accreditation model that includes three elements: student outcomes, self-assessment, and continuous improvement. According to Duff [3], outcomes assessment becomes most successful when everyone involved is fully vested in the process and there is continuous improvement woven throughout the process. The ABET accreditation model provides for the quality assurance of engineering programs through input from the stakeholders of the programs, a key aspect in improving outcomes in both engineering educational programs and engineering businesses [4] [5]. By including all the stakeholders in the quality assurance process – in this case employers, faculty, and students – the ABET model matches the common business models utilized to ensure continuous improvement of outcomes.

For example, Six Sigma, is a continuous improvement framework commonly used in manufacturing, whose use has been emerging in educational settings [4] [5].

Of all the stakeholders in engineering programs, employers consistently have the greatest voice. For example, the Engineering Criteria (EC2000) was developed as a response to feedback from employers regarding students and graduates in engineering undergraduate programs. Consistent with the EC2000 criteria, today's ABET criteria focus on program objectives and learning outcomes and not on specific engineering disciplines [6]. These student outcomes have sometimes been referred to as generic skills [2].

Despite the strength of the voices of engineering employers, it is engineering faculty who are most deeply involved in the accreditation process. ABET requires engineering programs to submit a self-study report as part of the accreditation or reaccreditation process [7]. In particular, a program must summarize the assessment of student performance and progress toward the required student outcomes, as well as provide information on how the program works toward continuous improvement of student learning outcomes [8]. Although the focus appears to be on students, the self-assessment reporting relies primarily on faculty input in determining and assessing student learning outcomes [8]. As part of the accreditation and reaccreditation process, student feedback on their achievement of the required outcomes is minimal, and often, superficial.

Additionally, with the accreditation self-study reports' reliance on faculty perspectives, the report is often based on existing teaching practices and preferred assessments (i.e., particular exam questions pass rate, written reports, etc.). The report may not consider the learning *process* students had during their course(s) or throughout their undergraduate program. In other words, assessment-centric self-study reports are not concerned with existing pedagogical practices and data on how and why engineering students achieve the desired competencies of the required outcomes.

Given the emphasis of ABET on continuous improvement, it is surprising, and antithetical to commonly accepted quality assurance and continuous improvement processes, that ABET processes do not formally require student perceptions of their achievement of the student outcomes. Although employers and faculty are both recognized as stakeholders and formally included in the process of assessing student outcomes, students are not. Students do provide feedback via course evaluations, exit surveys upon graduation, and some students may meet with advisory boards. Much of this feedback is at the course level or the program level and not the ABET assessment criteria (i.e. achievement or feedback on course activities as compared to learning outcomes). However, it is the students who are expected to achieve the desired learning outcomes by the end of the undergraduate program, and the omission of student feedback specifically on their ABET learning outcomes diminishes the importance of assessing teaching pedagogies that are critical components of students' attainment of outcomes.

A delimitation of this research is that it includes only those undergraduate students declared as an engineering major at the time of the survey distribution. This study did not address students outside of engineering majors. Additionally, another delimitation is the groupings are limited to those described above for academic grade level, gender, and race/ethnicity. Furthermore, the students were only surveyed one time and at the end of the academic year. This research study is also located at a single Midwestern research university; multiple universities and multiple regions are not included. In addition, other factors that can influence a student's perception of their generic skills competencies are not explored or controlled for in this research study.

Obtaining the students' perception of their levels of competency of all the desired student outcomes, or generic skills, could also provide valuable insight into students' development of these skills throughout undergraduate engineering programs. In summary, the ABET accreditation process of student outcomes, self-assessment, and continuous improvement fails to include the student as a key stakeholder in the process as it relates to their perceptions of their self-competency in the required student outcomes, resulting in a gap in understanding undergraduate engineering student learning and development.

Literature Review

The background of this research study stems from the need for quality assurance in engineering programs, continuous improvement models, student development, and assessment of student learning outcomes. Assessment and continuous improvement of student outcomes are key components of the ABET accreditation and re-accreditation process of higher education engineering programs. Furthermore, demographics of engineering students, such as gender and ethnicity, require further exploration related to their own perceptions of their self-competency in these learning outcomes required by ABET.

Quality Assurance of Engineering Programs

Quality assurance of undergraduate engineering programs is provided through the accreditation process. This process is an important aspect of engineering programs because many states rely on accreditation when it comes to professional licensures [9]. Furthermore, the process provides a guarantee for the students within the program and employers of program graduates that minimum quality standards have been met [10]. The accreditation process for engineering programs is typically done through ABET. ABET's process is built on three elements: student learning outcomes, self-assessment, and continuous improvement.

The student learning outcomes are defined by the different ABET commissions, such as the Engineering Accreditation Commission (EAC). The EAC provides seven general criteria for student outcomes within an engineering program. These outcomes are not program specific. The student outcome criteria include:

1. The ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. The ability to apply engineering design to produce solutions that meet specified needs, with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. The ability to communicate effectively with a range of audiences
4. The ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. The ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

6. The ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. The ability to acquire and apply new knowledge as needed, using appropriate learning strategies. [7]

Continuous Improvement Models

As detailed above, the quality assurance of undergraduate engineering programs is derived by three components: student outcomes, self-assessment, and continuous improvement. However, the continuous improvement of a program is many times at the discretion of the faculty during the self-reporting process, with minimal input from other key stakeholders. An important aspect of continuous improvement is utilizing feedback from all stakeholders in the process. For example, Six Sigma is a continuous improvement model that is used mainly in business settings, though it can also be applied to educational settings. There are five main steps when applying Six Sigma: define, measure, analyze, improve, and control [4]. A key component in applying these steps is stakeholder involvement.

Stakeholders are defined as a person or group who either affect or are affected by an organization's actions [11]. Zhao [12] proposed a framework to utilize Six Sigma as a part of quality management for improving the quality of higher education. The framework was based on five principles, the first of which defines the stakeholders in higher education: students, teachers, employers, and society [12]. Of these stakeholders, ABET accreditation already has mechanisms in place to allow for feedback from faculty and employers. However, it does not include a clear place for students, another key stakeholder, to provide feedback as to their learning and development of the expected student outcomes. Therefore, to understand student perspectives of their learning and development, understanding how undergraduate students develop from a theoretical perspective is essential.

Student Development

Student development is an important component in assessing student outcomes. Ultimately, it is a goal of higher educational institutions to aid in the development of the students throughout college to reach the desired outcomes required by accrediting organizations. Chickering and Reisser's theory of student development is a theoretical lens that lays the groundwork for undergraduate student development. The seven vectors included in their theory include developing intellectual competence, managing emotions, moving through autonomy toward interdependence, developing mature interpersonal relationships, establishing identity, developing purpose, and developing integrity. The seven vectors are tied to students' perceptions of their own development. Additionally, the seven vectors are not intended to be clearly defined from one another. Moreover, a student's development may overlap within the different vectors allowing for development to move fluidly between them [13].

In relationship to the ABET student outcomes criteria, Chickering and Reisser's vectors – intellectual competency, moving through autonomy toward interdependence, developing mature interpersonal relationships, developing purpose, and developing integrity – can be seen as key aspects of a student's development to attain competency in these generic skills. For example, the ABET student outcome criteria of the ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics is closely related to Chickering and Reisser's vector of development of intellectual competency. Another example is the ABET student outcome of the ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives, is closely related to both moving through autonomy toward interdependence and developing mature interpersonal relationships vectors.

The issue that readily becomes apparent with both the ABET student outcomes criteria and the vectors of student development is that they cannot necessarily provide a tangible result that can easily be assessed with a test question. Therefore, it is important to look at assessment strategies to understand fully the student's development and competency in the ABET student outcomes.

Assessment of Student Outcomes

Since the inception of accreditation, assessment has been an important part in higher education. Over the years, there have been many attempts to assess student outcomes. However, many times the data collected by faculty do not show how much a student is actually learning. In reality, faculty may only be assessing a student's "smartness" [14].

With the shift to the outcomes-based accreditation through ABET, engineering programs and faculty have been assessing student outcomes in a variety of ways. Assessment strategies have included pedagogy changes or theoretical lenses to determine student development and outcomes. However, many of the strategies are limited to singular activities, assignments, or courses, or are focused on a singular student outcome, such as teamwork, communication, or critical thinking. Furthermore, these practices often have been limited to the assessment made by the faculty. There is limited research not only on assessing student outcomes as they relate to all the ABET student outcomes criteria but also on student outcomes from the student perspective.

Engineering Student Learning Outcomes and Gender

Lehre, Hansen, Lehre, and Laake [15] found that women had a larger increase in average examination grades compared to men after the 2003 Quality Reform in the Norwegian Higher Education System. Additionally, the women outperformed men after the reform though prior to the reform men outperformed women [15].

However, Ro and Loya [16] found that women self-assessed engineering technical skill learning outcomes lower than their male counterparts, but their professional or generic skills were self-assessed to be higher than men. In a different study, the researchers found that depending upon the curricular emphasis, instructional approach and co-curricular participation could lead to a greater self-assessment of technical skills by women [17]. Overall, women reported lower levels of design or technical skills, if the course had a higher emphasis on generic skills; if the course was thought to be more of a student-centered teaching approach, women then self-assessed themselves higher than men on design or skills [17].

Chesbrough [18] also saw differences between gender in self-reported learning outcomes from service learning. In particular, learning about caring, social issues, community, and love all were statistically significant based upon gender [18].

Engineering Student Learning Outcomes and Race/Ethnicity

Using the intersectional approach to gender, Ro and Lova [17] saw differences in how participants self-assessed their learning outcomes when it came to race/ethnicity. Black women and men all assessed themselves lower compared to white participants. However, the study found that black women assessed themselves at a statistically significant lower rate than white women; the same comparison between black men and white men was not significant. Additionally, Asian men and men from other racial/ethnic backgrounds all assessed themselves lower than white men. However, Latinos actually assessed themselves higher in leadership skills and there were no differences in the other self-assessed learning outcomes as compared to white counterparts [17].

Methodology

The purpose of this study was to examine undergraduate engineering students' perceptions of their generic skills competencies across individual demographics at a research university located in the Midwest. The engineering programs associated with this study are those that are accredited through the Engineering Accreditation Commission of ABET. This study was accomplished using the Generic Skills Perception Questionnaire (GSPQ), a validated instrument used for undergraduate engineering students to report their perceptions of their competency in various generic skills, from very poor to very good.

Research Questions

The following research questions guided this study.

1. Are there mean differences in gender across academic grade level when the GSPQ is administered to undergraduate engineering students?
2. Are there mean differences in the majority race/ethnicity and minority race/ethnicities across academic grade level when the GSPQ is administered to undergraduate engineering students at a Midwestern research university?

Research Hypotheses

Below are the research hypotheses utilized for this study.

1. There will be mean differences for students' generic skill competencies in gender across academic grade levels at a research university in the Midwest.
2. There will be mean differences for students' generic skill competencies in majority race/ethnicity and minority race/ethnicities across academic grade levels at a research university in the Midwest.

Research Design Overview

This study utilized a survey research design. The survey research design allowed for a quantitative approach in analyzing the data and exploring relationships between the variables within the research questions. Furthermore, quantitative survey research of large sample populations made the study results more generalizable to other undergraduate engineering students.

This study sample was drawn from a Midwestern research university. The sample at this university was all undergraduate students that were a declared engineering major, as defined by the university's Registrar Office. This purposeful sampling approach allowed for a large sample population for the study.

The students were asked to participate in a survey to self-assess their competencies in generic skills. These generic skills tie closely to those outcomes required to be assessed by ABET accredited engineering programs. The survey was the recently developed and validated instrument, the Generic Skills Perception Questionnaire (Chan et al., 2017). The survey data and demographic information gathered enabled exploration of the relationships between variables. The data were collected utilizing an online survey platform, Qualtrics. The data were analyzed using quantitative methods via the computer program IBM Statistical Package for the Social Sciences (SPSS) Version 23. Specifically, beyond descriptive statistics, the research questions were answered and explored using analysis of variance (ANOVA) techniques. This design allowed examination of the relationship between a student's perception of their generic skills competency as they varied between gender and race/ethnicity.

Variables

Table 1 provides a consolidated list of the variables that were examined as a part of this research study. It also indicates which research question is applicable to the specific variable. For the purpose of this study, Academic Grade Level, which is defined as the number of credit hours earned, gender, and race/ethnicity are all considered independent variables.

Table 1

Variable Description Table

Variable	Type	Research Question	Analysis
GSPQ Scores	Dependent	1 & 2	
Academic Grade Level	Independent	1 & 2	
Gender	Independent	1	Two-way ANOVA
Race/Ethnicity	Independent	2	Two-way ANOVA

The Research Participants

The sample for this study consisted of engineering students enrolled in a Midwestern land grant university. The institution houses a large number of engineering students, as well as a variety of engineering disciplines typically found in engineering schools. Additionally, in order to be a declared engineering major, the student must have achieved a minimum composite score of 24 on the ACT or transfer into the major with a minimum GPA and be Calculus 1 ready. This was considered a purposive sampling method, because the criteria were deliberately set to select the sample population [19] (Gay & Mills, 2016). The purposive sample population was identified as those undergraduate students who were declared engineering majors during the Spring 2019 semester. The institution's information management office assisted in identifying the sample population at the institution. The sample population consisted of 2,277 undergraduate engineering students. The survey was sent to all students in the population via university email late in the Spring 2019 semester. The survey was administered via the Qualtrics survey platform provided by Oklahoma State University.

Instrumentation

The GSPQ instrument was used to acquire data on students' perceptions of their generic skills competencies. The original developers of the GSPQ instrument were Cecilia K.Y. Chan, Yue Zhao, and Lillian Y.Y. Luk from The University of Hong Kong.

The GSPQ is comprised of 35 generic skill items. A 5-point Likert scale is used for students to self-assess their current levels of competency in each skill. The Likert scale is from 1 (very poor competency level) to 5 (very good competency level). The generic skills are identified using learning outcomes expected from higher education institutions and accrediting organizations. In particular, the generic skills are identified from 12 domains of generic skills considered crucial in engineering from sources, such as ABET and the Hong Kong Institution of Engineers [2].

Drawing from these 12 domains, the instrument includes a 35-item questionnaire to aid in understanding students' perceived level of self-competence within each of the domains. Through both exploratory factor analysis and confirmatory factor analysis, the 35 generic skill items, provided for eight factors. The eight factors were Academic and Problem-Solving Skills, Interpersonal Skills, Community and Citizenship Knowledge, Leadership Skills, Professional Effectiveness, Information and Communication Literacy, Critical Thinking, and Self-Management Skills. The developers suggested the instrument could be used in different cultural contexts, although the original study was conducted only in Hong Kong. Furthermore, additional data on a cross-section of engineering students could provide more information because the original study was done on incoming freshmen [2].

In addition to the 35 generic skill items within the instrument, there was demographic questions to which students are asked to respond, including gender, ethnicity, and number of credit hours earned. Gathering the different demographics facilitated different analyses to answer the research questions.

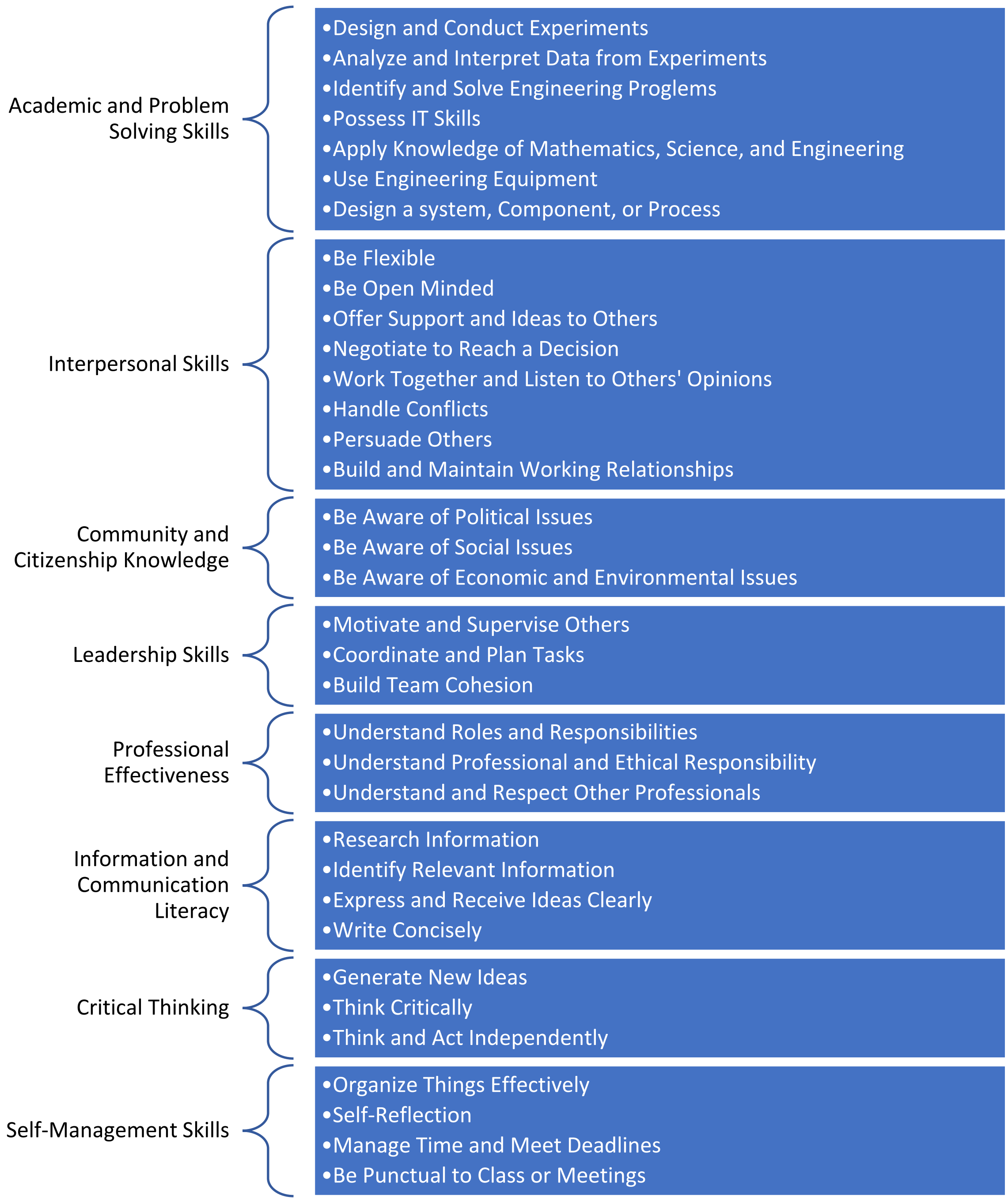

Figure 1. Generic Skills Perception Questionnaire Factors and Items [2]

Data Collection and Findings

The researcher obtained approval for the study from the Institutional Review Board at Oklahoma State University. The students selected as the sample population received an email inviting them to participate in the survey, via a hyperlink to a Qualtrics survey.

Data Analysis

From Qualtrics, the data were uploaded to IBM Statistical Package for the Social Sciences (SPSS) Version 23 for analysis. This study utilized both descriptive and inferential statistics to analyze the survey data. Descriptive statistics aided in the organization and described characteristics of a data set [20]. Descriptive statistics, such as mean, standard deviation, frequency, and ranges, were used for data grouping and data entry errors or omissions.

Inferential statistics were used to explore the relationships between the variables. The research questions – are there mean differences across different demographics across academic grade level when the GSPQ is administered to undergraduate engineering students – both used two different 2-way ANOVA designs, allowing each demographic factor to be compared to the GSPQ scores across the academic grade levels. The demographics that this study analyzed included gender (male or female) and majority race/ethnicity or minority race/ethnicities (White, Hispanic or Latino, Black or African American, Native American or American Indian, Asian/Pacific Islander, Other). The confidence interval for all the ANOVA designs was set at 95 percent. Results were considered significant at a 0.05 level.

Of the 2,277 students surveyed, there were 158 responses. Below are figures highlighting the demographic breakdown of the student respondents. Figure 2 shows the frequency of credit hours earned by the students that puts them into each academic grade level (0-29 freshman, 30-59 sophomore, 60-89 junior, and 90+ senior). Figure 3 gives the gender frequencies and Figure 4 provides the frequencies of the racial and ethnic background of the students. Since students were free to answer the question at their discretion, there were 16 missing values for all of the demographic response items, with the exception of race/ethnicity, in which there were 17 missing response items.

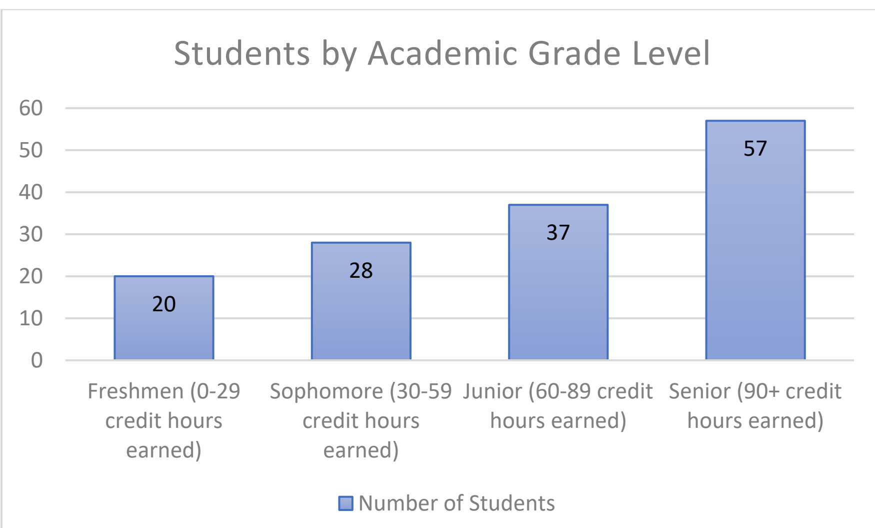

Figure 2. Distribution of Students by Academic Grade Level

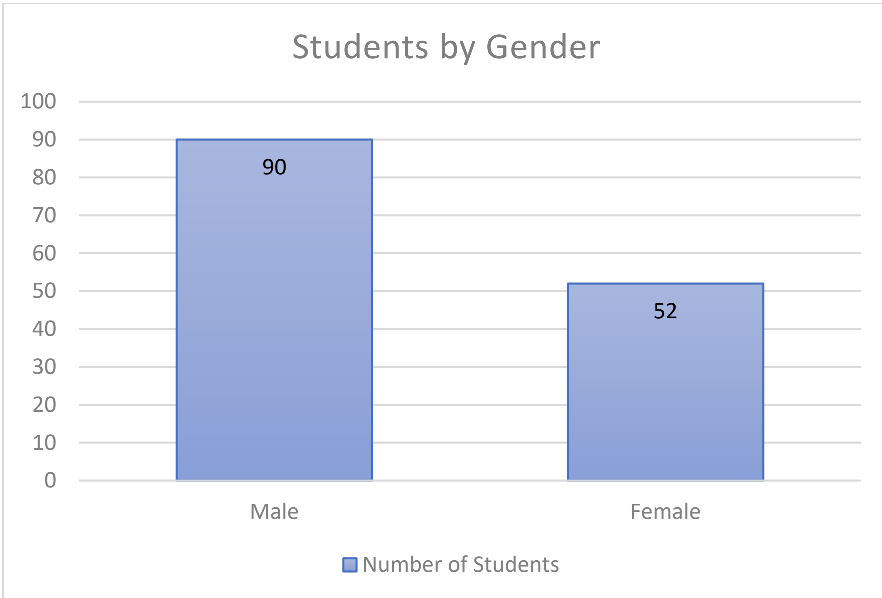

Figure 3. Distribution of Students by Gender

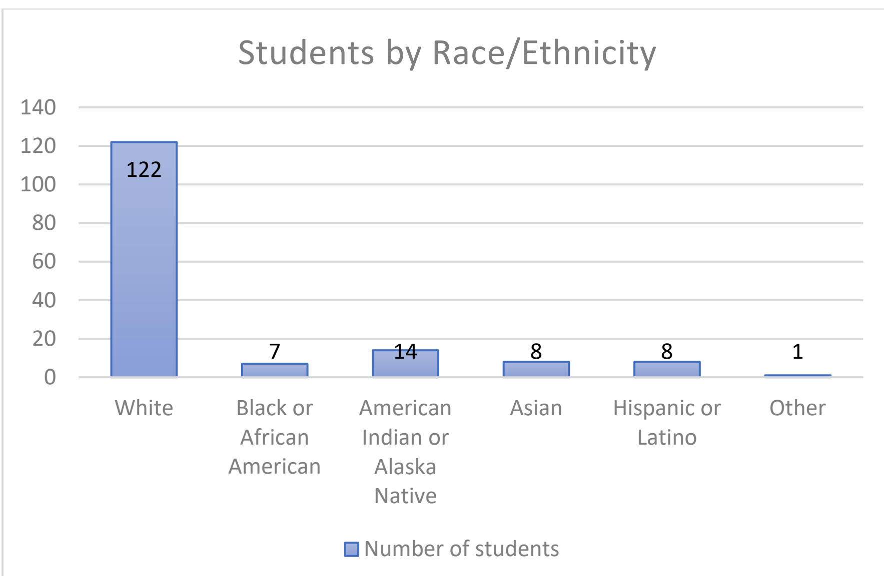

Figure 4. Distribution of Students by Race/Ethnicity.

Students were permitted to select all that applied for race/ethnicity and there were no students that reported themselves as Native Hawaiian or Pacific Islander. Based upon the responses, the majority race/ethnicity grouping was defined as white, while all other race/ethnicities were defined as the grouping of minority race/ethnicity.

Gender

The first research question explored differences of students' gender across the academic grade levels for the GSPQ items. As such, two-way ANOVAs were utilized to complete this analysis. Within SPSS, students were coded either as "male" or "female" based upon their response. Below are the findings of this analysis, beginning first with any items that indicated significance at the interaction and the subsequent reported simple main effects, followed by those showing significance only at the main effects, and all remaining items that were not significant at either the interaction or the main effects. Effect sizes were calculated using omega-squared (ω^2) for ANOVA tests and eta-squared (η^2) for Kruskal-Wallis tests.

The interaction of academic grade level and gender of the following items were found to be significant. For the items that had homogeneity of variance, Being Flexible ($F(3, 133) = 2.228$, $p < 0.10$, $\omega^2 = .0.026$) and Self Reflection ($F(3, 134) = 2.425$, $p < 0.10$, $\omega^2 = .030$), were found to have significance. The simple main effects were then reviewed for these items.

For the item Being Flexible, the simple main effect showed significance for senior women (M=4.58, SD=.507) reporting higher levels of competency than senior men (M =3.97, SD=.944), with a p-value of 0.007. For the item Self-Reflection, the simple main effects showed significance for sophomore women (M=4.31, SD=.630) reporting higher levels of competency than sophomore men (M=3.47, SD=1.060), with a p-value of 0.012). Furthermore, competency levels of Self-Reflection varied for academic grade level within men, with a p-value of 0.085. Tables 2 and 3 summarize the means and standard deviations for the simple main effects by significant item.

Table 2

Research Question 1 Simple Main Effects Means (M), and Standard Deviations (SD) by Gender for Academic Grade Level

Survey Question	Academic Grade Level	Male M (SD)	Female M (SD)
Being Flexible	Senior	3.97 (.944)	4.58 (.507)
Self-Reflection	Sophomore	3.47 (1.060)	4.31 (.630)

Table 3

Research Question 1 Simple Main Effects Means (M), and Standard Deviations (SD) by Academic Grade Level for Men

Survey Question	Freshman M (SD)	Sophomore M (SD)	Junior M (SD)	Senior M (SD)
Self-Reflection	4.00 (.961)	3.47 (1.060)	4.13 (.694)	4.11 (.953)

There were several items that did not have significance at the interaction, but the main effects were found to be significant. For the items that had homogeneity of variance, the main effect of Academic Grade Level was found to be significant for Design System Component or Process ($F(3, 134) = 3.664$, $p < 0.05$, $\omega^2 = .054$) and Think Critically ($F(3, 134) = 2.449$, $p < 0.10$, $\omega^2 = .030$).

Post-hoc analysis utilizing LSD, found that significance pairwise at $p<0.05$ for Design a System, Component, or Process at the Sophomore to Junior and Sophomore to Senior, as well as significance pairwise at $p<0.10$ for Freshmen to Senior. For Think Critically, post-hoc analysis showed significance pairwise at $p<0.05$ for Freshman to Sophomore and Sophomore to Senior. Table 4 details the means and standard deviations for the significant items.

For the item Be Aware of Political Issues, homogeneity of variance was violated, the interaction was not significant, but the main effect of academic grade level was shown to be significant. After further review via one-way ANOVA and ultimately the Kruskal Wallis test, this item was significant (χ^2 (3) = 10.921, $p < 0.05$, $\eta^2 = .077$).

For items with homogeneity of variance, the main effect of gender was found to be significant for Being Open-Minded ($F(1, 134) = 6.601$, $p < 0.05$, $\omega^2 = .039$), Understand and Respect Other Professionals ($F(1, 134) = 2.797$, $p < 0.10$, $\omega^2 = .013$), Write Concisely ($F(1, 134) = 3.401$, $p < 0.10$, $\omega^2 = .017$), and Organize Things Effectively ($F(1, 134) = 6.150$, $p < 0.05$, $\omega^2 = .036$). For all items in which the main effects were significant for gender, women reported higher levels of competency than men. Table 5 summarizes the means and standard deviations for the items of significance. All other items were not found to be significant at the main effects level.

Table 4

Research Question 1 Main Effects Test Value, Means (M), and Standard Deviations (SD) by Academic Grade Level

Survey Question	Test Value	Freshman M (SD)	Sophomore M (SD)	Junior M (SD)	Senior M (SD)
Design System, Component or Process	F(3, 134) = 3.664*	3.45 (.686)	3.18 (1.090)	3.65 (.909)	3.88 (1.019)
Think Critically	F(3, 134) = 2.449	4.35 (.813)	3.93 (.604)	4.14 (.713)	4.35 (.719)

*indicates significance at the p<0.05 level, all others at p<0.10 level

Table 5

Research Question 1 Main Effects Test Value, Means (M), and Standard Deviations (SD) by Gender

Survey Question	Test Value	ω^2	Men M (SD)	Women M (SD)
Being Open Minded	F(1, 134) = 6.601*	.039	4.16 (.806)	4.50 (.542)
Understand and Respect Other Professionals	F(1, 134) = 2.797	.013	4.31 (.802)	4.50 (.577)
Write Concisely	F(1, 134) = 3.401	.017	3.78 (.957)	4.04 (.839)
Organize Things Effectively	F(1, 134) = 6.150*	.036	3.96 (.935)	4.37 (.715)

*indicates significance at the $p<0.05$ level, all others at $p<0.10$ level

The first hypothesis proposed that there would be differences in the GSPQ measures across gender across academic grade levels. This only held true for Being Flexible and Self Reflection. Upon review of the Main Effects for the remaining items, Design a System Component or Process and Think Critically were significant for Academic Grade Level, while Being Open-Minded, Understand and Respect Other Professionals, Write Concisely, and Organize Things Effectively were significant for Gender. All other items were not found to be significant at either the interaction or main effects.

Race/ethnicity

The second research question explored differences of students' race/ethnicity across the academic grade levels for the GSPQ items. In particular, it explored differences of students between the majority race/ethnicity (White) and the minority race/ethnicities. As such, two-way ANOVAs were utilized to complete this analysis. Within the questionnaire, the students were given a list of race/ethnicities from which to choose including:

1. White
2. Black or African American
3. American Indian or Alaska Native
4. Asian
5. Native Hawaiian or Pacific Islander
6. Hispanic or Latino
7. Other (please list)

The majority of respondents selected "White" (122), compared to those that selected one of the minorities (totaling 38 responses), the respondents were coded as either the majority race/ethnicity (i.e. White), coded as 1, to the minority race/ethnicities (Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or Pacific Islander, Hispanic or Latino, or Other), coded as 0. Below are the findings of this analysis, beginning first with any items that indicated significance at the interaction and the subsequent simple main effects, followed by those showing significance only at the main effects, and all remaining items that were not significant at either the interaction or the main effects. Effect sizes were calculated using omega-squared (ω^2) for ANOVA tests and eta-squared (η^2) for Kruskal-Wallis tests.

No items found significance at the interaction. However, there were several items that showed significance at the main effects. For items with homogeneity of variance, the main effect of race/ethnicity was found to be significant for Being Flexible ($F(1, 134) = 5.146$, $p < 0.05$), Being Open-Minded ($F(1, 134) = 3.279$, $p < 0.10$), and Build and Maintain Working Relationships ($F(1, 134) = 3.380$, $p < 0.10$).

Table 6

Research Question 2 Main Effects Test Value, Means (M), and Standard Deviations (SD) by Race/Ethnicity

Survey Question	Test Value	ω^2 or η^2	Majority Race/Ethnicity M (SD)	Minority Race/Ethnicities M (SD)
Being Flexible	F(1, 134) = 5.146*	.029	4.12 (.799)	4.53 (.513)
Being Open-Minded	F(1, 134) = 3.279	.016	4.25 (.734)	4.58 (.507)
Build and Maintain Working Relationships	F(1, 134) = 3.380	.017	3.92 (.959)	4.32 (.671)
Be Aware of Political Issues	χ^2 (1) = 5.061*	.033	3.35 (1.135)	4.00 (.816)
Be Aware of Social Issues	χ^2 (1) = 3.167	.022	3.57 (1.071)	4.05 (.705)
Understand and Respect Other Professionals	F(1,139)=3.844	.020	4.36 (.693)	4.68 (.478)

*indicates significance at the p<0.05 level, all others at p<0.10 level

There were several items that violated homogeneity of variance (i.e. Levene's statistic was found to be significant) and the interaction was not significant, so a review of the main effects was completed using one-way ANOVA. Where the homogeneity of variance for the one-way ANOVA was maintained, Understand and Respect Other Professionals ($F(1,139)=3.844$, $p<0.10$), was found to be significant. For several of these items, the Kruskal Wallis Test was applied (due to homogeneity of variance being violated in the one-way ANOVA analysis), resulting in the following items being significant: Be Aware of Political Issues ($\chi^2 (1) = 5.061$, $p < 0.05$, $\eta^2 = .036$), and Be Aware of Social Issues ($\chi^2 (1) = 3.167$, $p < 0.10$, $\eta^2 = .022$). For each of these items, the Minority Race/Ethnicities reported higher levels of competency than the Majority Race/Ethnicity. Table 6 summarizes the main effects means and standard deviations for those items with significance.

For the item Be Aware of Political Issues, homogeneity of variance was violated, the interaction was not significant, but the main effect of academic grade level was shown to be significant. After further review via one-way ANOVA and ultimately the Kruskal Wallis test, this item was significant (χ^2 (3) = 10.921, $p < 0.05$, $\eta^2 = .077$).

The second hypothesis proposed that there would be differences in the GSPQ measures across race/ethnicity across academic grade levels. This hypothesis was rejected, as none of the items were found to be significant at the interaction. However, the items of Being Flexible, Being Open-Minded, and Build and Maintain Working Relationships, Be Aware of Political Issues, Be Aware of Social Issues, and Understand and Respect Other Professionals were found to be significant at the main effects for Race/Ethnicity, all of which had the minority race/ethnicities reporting higher levels of competency than the majority race/ethnicity. All other items were not found to be significant at either the interaction or main effects.

Discussion

The first research question was, are there mean differences in gender across academic grade level when the GSPQ is administered to undergraduate engineering students? This question was analyzed utilizing 2-way ANOVA to compare the mean differences for gender across the academic grade levels.

At the intersection of the two independent variables (gender and academic grade level), two items were found to be significant, Being Flexible and Self-Reflection. Reviewing the simple main effects, senior women reported higher levels of competency than their counterpart men for Being Flexible. Additionally, sophomore women also reported higher levels of competency than sophomore men for Self-Reflection. Also, there was significance in the reported competency within among men' academic grade level for Self-Reflection.

Reviewing the main effects, three items were significant across academic grade level, Design System, Component, or Process, Be Aware of Political Issues, and Think Critically. The difference was at the sophomore level, with all items seeing a dip in the reported competency level.

Reviewing the main effects for gender, four items were found to be significant: Being Open Minded, Understand and Respect Other Professionals, Write Concisely, and Organize Things Effectively. For all of these items, women reported higher levels of competency than men.

Interestingly, for either the simple main effects or the main effects for gender, women showed a higher level of competency. Given the male dominated environment of engineering disciplines, this provides insight as to where women may feel more confident in themselves. Two of the items were within the factor of Interpersonal Skills (Being Flexible and Being Open Minded), two of the items were within Self-Management Skills (Organize Things Effectively and Self-Reflection), and one item was a part of Professional Effectiveness (Understand and Respect Other Professionals). All of these factors are more soft skill oriented. Only one skill was more technical in nature, which could be debated, and that was Write Concisely within the factor of Information and Communication Literacy. This is consistent with the findings of Ro and Loya (2015) in that women consistently self-assess themselves higher than men in professional or generic skills, but in contrast to Ro and Knight (2016) that women reported lower levels of design or technical skills.

The second research question was, are there mean differences in majority race/ethnicity and minority race/ethnicities across academic grade level when the GSPQ is administered to undergraduate engineering students at a Midwestern research university? This question was analyzed utilizing 2-way ANOVA to compare the mean differences for the majority race/ethnicity compared to the minority race/ethnicities across the academic grade levels. Due to the responses selected by students, White was the overwhelming majority race/ethnicity and the remaining race/ethnicities (Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or Pacific Islander, Hispanic or Latino, Other) were considered the minority race/ethnicities.

In summary, the interaction of academic grade classification and race/ethnicity were not significant for any item. However, there were six items that showed significance at the main effects for race/ethnicity. The six items were Being Flexible, Being Open-Minded, Build and Maintain Working Relationships, Be Aware of Political Issues, Be Aware of Social Issues, and Understand and Respect Other Professionals. For all of the items, the minority race/ethnicities perceived themselves as more competent than their white counterparts (majority race/ethnicity).

This finding is in contrast to what Ro and Loya [16] reported. Their findings indicated Blacks and Asians reported lower learning outcomes and Latinos either had no difference or reported higher levels of learning outcomes in leadership skills [16]. Due to the response numbers, this study did not examine further breakdowns of the minority race/ethnicities and comparisons across these groups, however, this finding should be further researched within the different minority race/ethnicities.

Looking at the items themselves, three items were part of the factor Interpersonal Skills (Being flexible, Being Open-Minded, Build and Maintain working Relationships). Two items were part of Community and Citizenship Knowledge (Being Aware of Political Issues and Being Aware of Social Issues). The final item, Understand and Respect Other Professionals, is part of the factor Professional Effectiveness. All of these items are generic soft skills, as compared to generic technical skills. Additionally, some of these items could potentially be explained based on the different cultures of the reported minority race/ethnicities. For example, minority race/ethnicities, many times, have to be flexible and open minded as they may be working with others that are not the same race/ethnicity as themselves. Or minority race/ethnicities may have a better grasp on political and social issues based upon their upbringing. However, there was a small sample size of the minority/ethnicities, so further research of these differences should be explored with larger sample sizes.

When reviewing the effect sizes for both research questions, all omega-squared (ω^2) values met the threshold to be considered a small effect. Only the eta-squared (η^2) effect size was considered to be a medium effect size. This demonstrates that there is some relationship between the variables and it should be explored further.

An important item to discuss is the small sample size and response rate. Although over 2,000 students received access to the survey (all declared engineering majors) only 158 responded. This may be explained in a couple ways. First, is the survey was completed late in the spring semester, during which students may not have time to answer a survey. Second, the survey was distributed on the University's email platform and there was no incentive given to answer the survey, it was purely voluntary. Although the survey was sent several times, the response numbers diminished each time it was distributed. In future studies, it is recommended to provide incentives to answer the survey and work with instructors to allow time for responding in class. Additionally, it may add value to use the survey in a different time of year.

This study only looked at a snapshot of time of a student's perception of themselves and these generic skills. Another recommendation would be to add control variables such as prior academic performance to determine if student responses of their perceptions may correlate to their academic performance. Although students at this institution cannot declare an engineering major unless certain parameters are met (ACT/SAT scores or Math readiness), understanding the prior performance can add further argument the need to support underrepresented minorities early on in the academic process.

Conclusions

There continues to be a big push to increase the number of women in STEM fields, which includes engineering. This study revealed that women perceive themselves as more competent than men when it comes to several of the softer generic skills. This adds to the body of knowledge that although men may be the majority in engineering, women add value by being seeing themselves as more competent in different skillsets than men. This does not diminish either genders' knowledge on the technical aspects of their given field but adds value on what women can contribute to the engineering profession. The skills in which women indicated higher levels of competency are those skills that are often sought by employers.

Similar to the push to increase the number of women in engineering, there is also a charge to increase the number of engineers from minority racial and ethnic groups. The findings of this study were in contrast to previous studies, in that this study found that students from minority groups perceived themselves as more competent in several of the softer generic skills. This contradiction makes it apparent that implications for these groups should be further explored to gain a better understanding of their perceptions of their competencies. Additionally, the small number of responses from minority students in this study limits generalizability beyond this study. This begs further in-depth study to gain a better understanding of minority engineering students.

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