BUILDING A BETTER ENGINEER AND ROUNDING OUT ASSESSMENT: STUDENT PERCEPTIONS OF THEIR GENERIC SKILLS COMPETENCY

By

VIRGINIA CHARTER

Bachelor of Science in Engineering Technology
Fire Protection and Safety Engineering Technology
Oklahoma State University
Stillwater, Oklahoma
2005

Master of Science in Fire Protection Engineering
Worcester Polytechnic Institute
Worcester, Massachusetts
2012

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
December, 2019

BUILDING A BETTER ENGINEER AND ROUNDING OUT ASSESSMENT: STUDENT PERCEPTIONS OF THEIR GENERIC SKILLS COMPETENCY

Dissertation Approved:

Dr. Stephen Wanger

Dissertation Adviser

Dr. Amber Manning-Oullette

Dr. Mwarumba Mwavita

Dr. Heather Yates

ACKNOWLEDGEMENTS

First and foremost, I would like to acknowledge and thank the forever loving support from my husband, Dustin Charter. Without your support and your willingness to go through this process with me, it would have never been possible. I love you always and am looking forward to being with you without this hanging over my head.

My children, Parker, Asher, and Luella, you have sacrificed more than you may know. Mommy missed things in your lives for being in class and had to work while you played. I hope the hurt in my heart for being away was more than you ever felt. My love for all three of you puts a smile on my face and you all make me want to be a better person and mom. Each of you experienced this process differently, but I hope that you saw the effort and dedication needed and I pray that you do the same as you grow and learn in life. You three will all always have a piece of my heart.

To Tara Roberson-Moore, Megan Pitt, Rachel Mosier, Melissa Hamby, and Courtney Savage. Thank you for reviewing my work, listening to me talk through something, vent, watch my children, or just being my friend. Without these friendships, I would not be where I am today.

To my "cohort" Megan Pitt and Mike Breslin, thank you for enduring it all together. I will be your cheerleader to the finish line just like you were mine.

To those on my committee, Dr. Heather Yates, you are more than a committee member and program coordinator, but you are a mentor and friend. Dr. Amber Manning-

Oullette, thank you for your willingness to be on a committee during your first year at OSU and through your own experiences of becoming a mother. Your thoughtfulness and critiques have been very valuable to me and I look forward to working with you in the future. Dr. Mwarumba Mwavita, thank you for your patience and time in aiding in my data analysis. I truly enjoyed every meeting I have had with you talking numbers and data. And Dr. Stephen Wanger, thank you for taking on another PhD student when I know you had too much on your plate and pushing me to improve my writing and research study. I am forever grateful to my committee for making this process go as smoothly as it did.

Name: VIRGINIA CHARTER

Date of Degree: DECEMBER, 2019

Title of Study: BUILDING A BETTER ENGINEER AND ROUNDING OUT ASSESSMENT: STUDENT PERCEPTIONS OF THEIR GENERIC SKILLS COMPETENCY

Major Field: EDUCATIONAL LEADERSHIP & POLICY STUDIES

Abstract: Within higher education engineering programs, there are several stakeholders that are vested in programs success, including students, faculty, and employers. Each of these stakeholders provide a different perspective of the assessment of the skills that engineering programs pursue to develop. Faculty seek to teach the necessary technical and soft skills to students. Employers hope to hire students that graduate from programs that have attained these skills. And students strive to develop and learn the necessary skills to be successful after graduation. Referred to as generic skills, are those skills that can be used in contexts beyond a specific discipline and are not isolated to knowledge within a particular academic or professional field (Bennett et al., 1999). Examples of these generic 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 (Chan et al., 2017).

This study explored undergraduate engineering students' perceptions of their generic skills competency across academic grade level, pre-graduation engineering experiences, and individual demographics at a research university located in the Midwest. This study was accomplished using the Generic Skills Perception Questionnaire (GSPQ). Additional demographic data were also obtained. Overall, students perceived themselves as competent in both the technical and soft generic skills. Although differences were found among the academic grade level, only a few items were considered significantly different. Many of the skills indicated that students that have had pre-graduation engineering experiences saw themselves as significantly more competent than students without pre-graduation engineering experiences. Females indicated higher levels of perceived competency in several of the generic soft skills than their male counterparts. Additionally, the minority racial and ethnic students perceived themselves as more competent than their white peers for several of the generic soft skills. These findings have implications on theory, research, and practice and future research beyond this study can further explore student perceptions in order to build a better engineer.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

Numerous stakeholders, including, the public, employers, and students, call for accountability and quality measurement within higher education. Institutions and programs utilize accreditation, a third-party peer review system, to ensure educational quality and hold educators accountable. The Accreditation Board for Engineering and Technology, or ABET, is the organization that provides accreditation to engineering, engineering technology, and other engineering-related programs throughout institutions in the United States.

Aft (2002) describes basic steps of the ABET accreditation process, where each program must formally request accreditation, undergo a self-study including the completion of the self-study documentation, host a site visit by ABET assessors who draft a detailed report, and receive a final decision from the accreditation agency, ABET. This process is then repeated on a six-year cycle. There are several benefits of ABET accreditation, including assurances to prospective students and parents that a program meets minimum standards, evidence to employers that graduates are prepared for jobs, and accountability to taxpayers that their money is well spent (Aft, 2002). Thus, as Aft

(2002) describes, this accountability process leads to tangible benefits for the accredited programs, such as formal communication of accountability and quality assurance evidence to those entering ABET accredited programs.

However, given that employers and industry are the ones to gain the most benefit by hiring graduates from accredited programs, accreditation also gives employers the most staying power in what goes into the accreditation process as well as programmatic focus and content. In particular, employers were a driving force for the change in the accreditation of programs for ABET in the late 1990s (Prados, Peterson, & Lattuca, 2005). Employers contributed their input not only into the need of the accreditation process as a quality assurance mechanism, but also into the content of program accreditation. In other words, they wanted to emphasize what exactly programs needed to produce and demonstrate as a valuable program outcome.

Hiring industries indicate they want engineering graduates with not only technical capacity, but also strong communication, teamwork, problem solving and critical thinking skills (Prados et al., 2005). These skills indicated as important by employers (i.e. communication, teamwork, problem solving, and critical thinking) are considered generic skills as they can be used in contexts beyond an individual discipline (Bennett, Dunne, & Carré, 1999). Other terms, such as soft, employability, transferable, and professional skills are used in a similar manner. This emphasis by employers on these generic skills caused ABET to respond and modify accreditation requirements to include programs demonstrating that graduates were the complete package, from core technical skills that are discipline specific to the generic non-technical skills.

Measuring student experiences and outcomes in engineering higher education programs has become an important aspect in program specific accreditation. ABET developed and implemented mandatory revised criteria for the accreditation of engineering programs under the transition to the Engineering Criteria 2000 (EC2000) in 2001 (Prados et al., 2005). ABET's criteria focus on program objectives and student outcomes and not on specific engineering disciplines (ABET, 2018a).

The Engineering Accreditation Commission (EAC) for ABET accredits engineering programs in higher education. The 2019-2020 EAC student outcomes criteria are still based on the original EC2000 criteria from 2001, providing seven student outcomes that a program must document and assess. ABET (2018a) indicates that a student's attainment of the required student outcomes will prepare them to enter the professional practice of engineering. These student outcomes - which are subsequently examined - tie closely to those needs indicated by employers of graduates, from technical to non-technical.

To document the attainment of student outcomes, engineering programs must submit a self-study report during their accreditation or re-accreditation process. The self-study report relies primarily on faculty input in determining and measuring student outcomes. In particular, a program must summarize an observation mechanism of student performance and progress as well as a process of establishment and revisions of student learning outcomes. The self-study report also typically contains information on how a program works toward continuous improvement of the student outcomes. Finally, recent graduates' transcripts are additional supplemental data required for the inclusion in the reporting process (ABET, 2018b).

On a broader reach, accreditation is something that constantly pushes engineering programs. Accreditation is extremely important for graduates that go on to gain professional licensure and certifications in their fields of expertise. This professional emphasis on student preparation makes the student learning outcomes much more important. Therefore, not surprisingly, the ABET accreditation model centers on learning outcomes, self-assessment, and continuous improvement. However, the accreditation reporting model of the learning outcomes is built only on faculty perspective on existing teaching practices as well as their emphasis on assessment that may serve as a better indicator of achieved learning outcomes (i.e. particular exam questions pass rate, written reports, etc.) and it does not take into account the learning process itself that the student has had during their course(s). In other words, assessment-centric self-study reports are not concerned with existing pedagogical practices and data on how and why engineering students learn these generic skills and achieve professional competency of the required student outcomes.

Volkwein, Lattuca, Harper, and Domingo (2007) examined the impact of the EC2000 criteria on student outcomes. Their findings reaffirmed that the application of the new outcomes-based criteria was working without impact on technical knowledge (Volkwein et al., 2007). This demonstrated that the accreditation shift to student outcomes was a move in the right direction in improving the outcomes that employers wanted in graduates.

However, there are other studies that indicate improvements are still needed for achieving these student outcomes. Feutz and Zinser (2012) found graduates to be well prepared with regard to technical knowledge received within an engineering technology program. However, the graduates of this engineering technology program indicated a communication course taken in the curriculum held a lot of value in industry. Furthermore, graduates suggested that changes to the program should include the addition of a project management or business course, not a specific technical course (Feutz & Zinser, 2012).

Another study found a difference in what hiring managers perceived as a mastered skill by a graduate, compared to what the recent graduate saw themselves as having mastered. The skills that hiring managers saw as a gap in graduates were project management, communication skills, and organization (*Bridge that gap*, 2013). This demonstrates that there are differences in what employers and students see as achieving these generic skills.

The need for the well-rounded engineer has not changed in decades. As far back as 1918, Mann (1918) reported that 85% of job success came from having developed soft skills and only 15% of engineering job success came from the technical knowledge. Even since the EC2000 criteria was implemented as a part ABET accreditation, the National Academy of Engineering published a report in 2002 for the Engineer of 2020 Project. The committee that participated in the project indicated that future engineers should have the capability to solve problems, creativity, good communication skills, an understanding of business practices, leadership skills, ethics, and the ability to change; the engineer of 2020 should also be committed to life-long learning (National Academy of, 2004). However, as can be seen from the previously discussed research, there is a gap in the attainment of these skills when different stakeholders, such as students, faculty, and employers, are asked about the achievement of these skills.

Higher education institutions are charged with the responsibility to instill and grow these generic skills in the undergraduate students enrolled so that graduates can meet industry needs as future engineers. It is then through accreditation that engineering higher education programs must assess that these generic skills are being achieved at the level desired by employers. However, the current assessment strategies may not capture a complete picture of the students' competency of these generic skills.

The following pages describe the background of this dissertation, which includes key topics at the intersection of engineering undergraduate student outcomes. Additionally, this chapter introduces the research study's problem statement, purpose statement, research questions and hypotheses, research design overview, definitions of key terms, and the significance of the study.

Background

The background of this dissertation arises from the need for quality assurance in engineering programs, continuous improvement models, student development, and assessment of learning outcomes. Assessment and continuous improvement of student outcomes are key components of quality assurance in engineering programs in higher education, as well as the contribution to the overall development of undergraduate students.

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

(Eaton, 2012). Furthermore, the process provides a guarantee for the students within the program and employers of program graduates that minimum quality standards have been met (Aft, 2002). 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. (ABET, 2018a)

The self-assessment component of ABET accreditation is a task left to faculty via the self-study report submitted during the accreditation or reaccreditation process. This self-study report must provide information related to assessment and evaluation of student performance and growth toward the required student outcomes. ABET provides a broad overview of the design and implementation of assessment strategies that includes use of "direct, indirect, quantitative, and qualitative measures appropriate to the outcome or objective being measured", ultimately leaving it to the faculty to make decisions related to the assessment (ABET, 2018a).

The third component of ABET accreditation is continuous improvement. ABET requires programs regularly to evaluate the process utilized to assess student outcomes. The intent of the evaluation is to then systematically input continuous improvement for the program in achieving the student outcomes (ABET, 2018a). The area of continuous improvement is based upon the faculty process to assess student outcomes, with minimal outside input during the self-study report. With the emphasis of continuous improvement in the ABET accreditation process, it is important to look at the use of commonly accepted continuous improvement models.

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 (LeMahieu, Nordstrum, & Cudney, 2017). 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 (Taghizadegan, 2013). Zhao (2011) 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 (Zhao, 2011). 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 (Chickering, 1993).

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" (Astin, 2016).

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.

Problem Statement

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 (2004), 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 (LeMahieu et al., 2017; Marzagão & Carvalho, 2016). 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 (LeMahieu et al., 2017; Marzagão & Carvalho, 2016).

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 (Prados et al., 2005). These student outcomes have sometimes been referred to as generic skills (Chan, Zhao, & Luk, 2017).

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 (ABET, 2018a). 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 (ABET, 2018b). Although the focus appears to be on students, the self-assessment reporting relies primarily on faculty input in determining and assessing student learning outcomes (ABET, 2018b). 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. 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 diminishes the importance of assessing teaching pedagogies that are critical components of students' attainment of outcomes. 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.

Purpose Statement

The purpose of this study was to examine undergraduate engineering students' perceptions of their generic skills competencies across academic level, pre-graduation engineering experiences, and 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 dissertation.

The overarching research question was:

What are undergraduate engineering students' perceptions of their competency levels for generic skills at a Midwest research university?

The following sub-questions further guided this dissertation:

1. Are there mean differences across academic grade level when the GSPQ is administered to undergraduate engineering students at a Midwest research university?
2. Are there mean differences across academic grade level for undergraduate engineering students who had pre-graduation engineering experiences, as compared to undergraduate engineering students who did not have pre-graduation engineering experiences, when the GSPQ is administered to undergraduate engineering students at a Midwest research university?
3. Are there mean differences in gender across academic grade level when the GSPQ is administered to undergraduate engineering students?
4. 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. The variables and type of analysis are described in the subsequent section.

1. There will be mean differences for undergraduate engineering students' generic skill competencies across academic grade level at a research university in the Midwest.
2. Students with pre-graduation engineering experiences will score significantly higher on measures of generic skills competencies across academic grade levels at a research university in the Midwest.

3. There will be mean differences for students' generic skill competencies in gender across academic grade levels at a research university in the Midwest.
4. 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 research study was approached from an objectivist epistemology and a post-positivist theoretical perspective (Crotty, 1998). 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 academic grade level, pre-graduation engineering experiences, genders, and ethnicity.

Definitions of Key Terms

The areas of higher education, particularly engineering education, and student development have terms that are often unique to them. This section provides definitions of key terms to ensure clarity and meanings within the context of this study.

Generic Skills

The term "generic skills" is sometimes used interchangeably with terms such as soft skills or transferable skills. The developers of the Generic Skills Perception Questionnaire, Chan, Zhao, and Luk (2017), utilize the term generic skills from Bennett, Dunne, and Carre (1999) and the same definition will be used here. Generic skills are those skills that can be used in contexts beyond a specific discipline and are not isolated to knowledge within a particular academic or professional field (Bennett et al., 1999). Examples of these generic 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 (Chan et al., 2017).

Academic Grade Level

For the purposes of this study, academic grade level was based upon credit hours earned by the student. There were four classifications of undergraduate students: freshmen, sophomore, junior, and senior. Each of these classifications had an associated number of credit hours earned: 0-29 credit hours earned (freshmen), 30-59 credit hours earned (sophomore), 60-89 credit hours earned (junior), and 90 plus credit hours earned (senior).

Pre-Graduation Engineering Experiences

There are a variety of experiences that an undergraduate student can draw from throughout his or her academic career. Sometimes these can be considered as co-curricular activities. Co-curricular is defined by the Glossary of Education Reform (2019) as activities, programs and learning experiences that compliment what students may be learning in school. However, for the purposes of this study, students were grouped based on whether or not the student did or did not have a pre-graduation engineering experience. Pre-graduation engineering experiences included internships, cooperative programs, employment, service learning, engineering study abroad, and engineering competition teams. Internships within a student's field of study typically take place over the summer and may or may not count toward college credit. Cooperatives, or co-ops, are typically a multi-term agreement where a student works full time for a company within his or her field of study and alternates terms of work with school. Other employment is intended for students that may have part- or full-time employment within his or her field of study but is not considered to be an internship or a co-op. Service learning is an experiential learning activity where a student gains knowledge in his or her field of study while contributing to a local community. This could be accomplished through local organizations or even study abroad experiences. Finally, engineering competitions teams involve students working together to develop a solution or improvement to designs based upon the competition. The key to understanding pre-graduation engineering experiences is whether a student had an experience external to his or her academics that relates to engineering disciplines. Other co-curricular or extracurricular activities are not considered to be a pre-graduation engineering experience.

Assessment

Assessment is a common phrase used in multiple fields of study and industry. In the context of this study, assessment is the method or tools used by educators to evaluate, measure, and document academic readiness, learning, skill attainment, or general education needs of students (Reform, 2019).

Learning Outcomes

For the purposes of this study, Learning Outcomes are documented student outcomes that support a programs educational objectives (ABET, 2018a). The intent is that the attainment of these outcomes prepares graduates to enter the workforce, or in this study's case, the professional practice in engineering (ABET, 2018a).

Continuous Improvement

Continuous improvement is defined by the American Society for Quality (2019) as the ongoing improvement of products, services or process. In the context of this study and accreditation, ABET (2018a) has Criterion for Continuous Improvement where results of the assessments and evaluations of student outcomes should be systematically used for input for the continuous improvement of the program being assessed.

Delimitations

A delimitation of this dissertation 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, ethnicity, and pre-graduation engineering experiences. 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 in this research study.

Significance

The outcomes of this study may have significance for student learning and development in the areas of research, theory and practice. This study hopefully contributes to research of students' generic skills competencies at the undergraduate level, while adding to the understanding of student development theory, and contributing to the continuous improvement process of engineering academics.

Research

Although there has been much research devoted to assessing student learning outcomes, most included student self-assessment for singular skills (i.e. only communication, critical thinking, or teamwork, etc.), or for an assignment, or for a course. Limited research has been done on students assessing themselves for all the required student learning outcomes required by accrediting bodies, particularly ABET. Additionally, the GSPQ instrument has only been used for incoming engineering freshmen students in Hong Kong. This research sought to provide insight on differences in cultural contexts as well as a cross section of engineering students across academic grade levels at a Midwest research university.

Theory

Researching undergraduate engineering students' perceptions of their competency levels of all the student learning outcomes required by ABET may provide valuable information regarding undergraduate engineering students' development. In particular, this study sought to build upon student development theories such as Chickering and Reisser's theory of student development. Since the generic skills in the GSPQ can be related to several of Chickering and Reisser's seven vectors, the results of this study may provide valuable information as to when (academic grade level) or why (pre-graduation engineering experiences, gender, or ethnicity) students perceive themselves as having achieved these skills. This, in turn, may demonstrate their perception of their development through the different vectors.

This dissertation may also provide further linkage to student learning theories, such as Kolb's Learning Theory and Perry's Model of Intellectual and Ethical

Development. Kolb's Learning Theory may be related to looking at the pre-graduation engineering experiences and the impact of student perceptions of their competencies. Perry's Model of Intellectual and Ethical Development may be connected to the point at which students move into relativism and reach a higher level of critical thinking and problem solving.

Practice

This dissertation may add to engineering programs' continuous improvement processes and, more specifically, support the development and use of pedagogies to further develop the required student outcomes. This is especially true in understanding differences among engineering students across academic year, demographics, and pre-graduation engineering experiences.

The student outcomes required by ABET accreditation are closely related to the generic skills that Chan et al. (2017) utilize for the GSPQ instrument. This study can provide valuable information back into the accreditation process on assessing learning outcomes by including student perceptions.

Additionally, this study may provide insight into the students' perception of their achievement of these outcomes. This could be helpful to the students in their own reflection of their learning and workforce preparation. A comprehensive understanding of students' perceptions of their levels of competency can offer valuable insight to undergraduate engineering programs seeking to develop these generic skills. Furthermore, understanding differences among engineering students' development of generic skills based upon demographics or pre-graduation engineering experiences can help further develop curriculum and pedagogy to grow these generic skills.

Summary

In this chapter the context and background of the dissertation were provided. This chapter also introduced the dissertation's problem statement, purpose statement, research questions and hypotheses. An overview of the research design was included. Finally, the definitions of key terms and the significance of the research study were addressed. The following chapter reviews the relevant literature for this dissertation.

CHAPTER II

REVIEW OF THE LITERATURE

In Chapter One, the context and justification were presented regarding researching students' perceptions of their generic skills competencies. In this chapter, engineering student learning, student learning outcomes, assessment, and continuous improvement will be explored. Commonly accepted models of continuous improvement as a part of a quality assurance processes will be presented. The literature review will then discuss the use of accreditation to provide accountability for student learning in higher education and then sketch the development and role of ABET as an accrediting agency for engineering programs. Next, various student development and learning theories, and those commonly utilized in engineering, will be presented. The literature review will then discuss engineering student learning outcomes and the continued reported industry skills gap. The different assessment strategies utilized for engineering student learning outcomes will be discussed. Finally, engineering students' individual demographics and student learning outcomes will be explored.

Commonly Accepted Models of Continuous Improvement

For many years, people have attempted continuously to improve processes around them. There are several formalized continuous improvement models, such as Just-in-

Time, Benchmarking, Kaizen, International Organization for Standardization, Business Process Reengineering, and Six Sigma. Each of these models emerged to provide quality assurance and continuous improvement to different processes, such as manufacturing, business, and waste reduction (Samman & Ouenniche, 2016). According to Samman and Ouenniche (2016), all of the above continuous improvement models include ten critical success factors including: (1) implementation scope, (2) knowledge, education and training and adaptation of concepts underlying a program and the appropriate tools, (3) supply chain integration, (4) work organization, planning, and scheduling, (5) organizational structure and culture, (6) management and employees involvement, support and commitment, (7) technology, (8) design of quality teams, (9) strategy, and (10) methodology and tools for performance measurement. Although the former is descriptive of a business or manufacturing process, continuous improvement models, such as Six Sigma, have been emerging in the higher education sector. Six Sigma will be presented here in detail.

Six Sigma is a continuous improvement model that is many times used in business settings, though it can be applied to educational settings. Six Sigma was developed in the 1980s by Motorola to reduce the number of defects in manufactured products to only 3.4 defects per million opportunities (Zhao, 2011). When applying Six Sigma, there are five main steps as shown in Figure 2.1: define, measure, analyze, improve, and control (LeMahieu et al., 2017). 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 (Taghizadegan, 2013). An important aspect of quality assurance and continuous improvement is utilizing feedback from all stakeholders in the process. Without the feedback of all stakeholders, the difficulty in implementing the five steps increases.

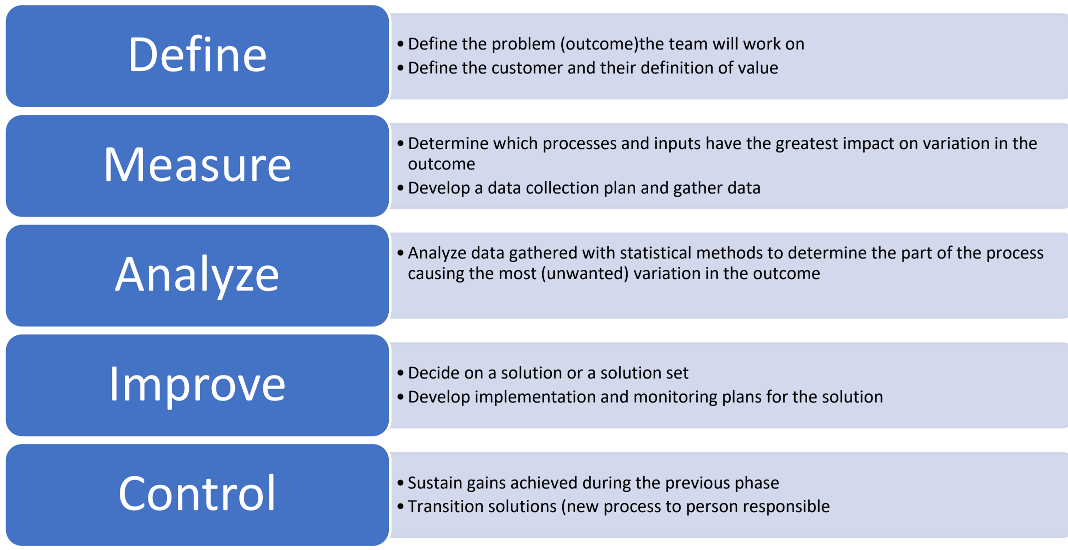

Figure 2.1. The DMAIC roadmap in Six Sigma (LeMahieu et al., 2017)

Zhao (2011) 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: concern for students, teachers, employers and society, making decisions based upon data and facts, focusing on process management, emphasizing team work, and developing a continuous spirit of innovation (Zhao, 2011). The first principle details the main stakeholders of a quality assurance program within a higher education program, namely, the students, teachers, employers, and society. This principle is particularly important, as it drives the rest of the framework principles.

Continuous improvement and quality assurance are phrases commonly spoken together. So, it is only natural for higher education to utilize a process that will aid in the continuous improvement of programs and institutions. This process of quality assurance and continuous improvement is formalized through accreditation.

Accountability of Student Learning through Accreditation

Merriam-Webster defines the word accredit “to recognize (an educational institution) as maintaining standards that qualify the graduates for admission to higher or more specialized institutions or for professional practice” (Merriam-Webster, 2017). For more than 100 years, the accreditation process provided colleges, universities, and programs quality assurance and improvement. Higher education accreditation in the United States came about from the need to protect public health and safety and to serve the public interest (Eaton, 2012).

In recent decades, accreditation included a focus on student-learning outcomes. One of the most notable discussions on higher education quality came from The Secretary of Education’s Commission on the Future of Higher Education in 2006. Also in 2006, and in a critique of the accreditation process, Schray asked: “How can the accreditation system be held more accountable for assuring performance, including student-learning outcomes, in accrediting institutions and programs?” (p. 1). This question continued to be asked as assessing student-learning outcomes increasingly became an important aspect of higher education.

Accreditation Process

There are two main types of educational accreditation. The first is the institution’s accreditation that evaluates the institution, as a whole, in quality. This is normally done by regional organizations such as the Higher Learning Commission. The second type of accreditation is that of specialized programs. This type of accreditation evaluates specific programs to determine if the program graduates are prepared to enter the profession (Aft, 2002).

In contemporary higher education, there are four types of accrediting organizations: regional accreditors, national faith-related accreditors, national career-related accreditors, and programmatic accreditors. Seven regional accreditors accredit public and private institutions comprised mainly of nonprofit two- and four-year degree granting institutions. Five faith-related accreditors focus on nonprofit and degree-granting religiously affiliated institutions. Seven career-related accreditors are for mostly for-profit, career-based, and single-purpose institutions that may be degree or non-degree granting. Programmatic accreditors accredit specific programs, professions, and freestanding schools; examples of these specialized programs include law, medicine, engineering, and other health professions. There are currently 79 programmatic accrediting organizations (Eaton, 2012).

For either institutional or program-specific accreditation, the process typically includes self-study, peer review, site visits, judgment by accrediting organization, and periodic peer review. The self-study includes a written summary prepared by the institution or program regarding the institution's or program's performance based on the accrediting standards. Faculty and administrators who are peers in the profession, as well as non-academic volunteers, conduct the peer review and, as a part of the process, review the self-study report. The accrediting organization then provides a judgment based upon the self-study, peer review, and site visit that affirms accreditation for new institutions and programs, reaffirms accreditation for ongoing institutions and programs, or denies accreditation to institutions and programs (Eaton, 2012).

Benefits of Accreditation

There are several important benefits to having an accredited institution or program within higher education. According to Aft (2002), accreditation provides students and parents the guarantee that a program has met minimum standards, gives employers the assurances that graduates are prepared for industry, and provides taxpayers the confidence that money is well spent on higher education. Federal and state governments also rely heavily on accreditation and its role in facilitating academic quality. This is particularly important when it comes to federal funding for financial aid to students, but states also emphasize the importance of accreditation when they require individuals who request various professional licensures to have graduated from accredited institutions and programs (Eaton, 2012).

Employers and industry gain the most benefit by hiring graduates from accredited programs. Accreditation helps verify and evaluate the credentials of job applicants. Furthermore, employers and industry may also use accreditation as a reason to provide tuition support for employees furthering their education (Eaton, 2012). Another reason for accrediting institutions and programs is the ease of transferring courses or credits between institutions. Although there may be many factors that a given institution reviews considering transfers, accreditation gives them the assurance of the quality of the credits previously earned by a student (Eaton, 2012).

Recognizing Accrediting Organizations

Accreditation of institutions or programs is a nongovernmental activity, whereas recognition of an accrediting organization can be a governmental activity. Accreditors undergo an external review, often by the Council for Higher Education Accreditation

(CHEA) and/or the United States Department of Education (DOE), to legitimize their "recognition" (Eaton, 2012). Each of these organizations has differing criteria for recognition (Schray, 2006).

Within the DOE standards for recognition of accrediting organizations, student achievement is the criterion that most closely relates to student learning and student-learning outcomes. The governmental criterion for student achievement emphasizes course completion, state licensure, and job placement within the mission of the institution (U. S. D. o. Education, 2017).

Within CHEA, the Committee on Recognition utilizes the criterion for academic quality to scrutinize student-learning outcomes within the context of the institution or program mission. Therefore, CHEA permits the different accrediting organizations to establish the standards for student learning, and student-learning outcomes need to be met for those programs and institutions to become accredited (Accreditation, 2010).

Accreditation of and Student Learning Outcomes in Engineering Programs

The Accreditation Board for Engineering and Technology, which changed its official name to be only ABET, is the organization that provides accreditation to engineering, engineering technology, and other engineering-related programs throughout institutions, mostly within the United States. Since ABET is a specialized or programmatic accrediting organization, ABET is currently only recognized by CHEA and does not carry the DOE recognition (Accreditation, 2010). ABET has a long history of the development and evolution of student-learning outcomes in engineering.

In the early 1900s, U.S. higher education engineering disciplines were a combination of a formal mathematical and scientific system in addition to an apprenticeship system (Prados et al., 2005). However, in the 1920s, there was a shift toward a more theoretical foundation, but maintained practical application through faculty that had significant industry experience (Prados et al., 2005). During the World War II era, another shift occurred toward the hiring of strong research faculty which resulted in little to no emphasis on practical application and a heavy emphasis on math and sciences theory (Prados et al., 2005).

ABET transitioned to an outcomes based model through the development of the Engineering Criteria 2000 (EC2000) in 1995 and achieved full implementation for all programs in 2001 (Prados et al., 2005). ABET's criteria now focus on program objectives and learning outcomes (ABET, 2018a). The Engineering Accreditation Commission (EAC) accredits engineering programs for ABET (ABET, 2018a; Prados et al., 2005).

Aft (2002) describes basic steps of the ABET accreditation process, where each program must request accreditation, undergo a self-study, host a site visit by ABET assessors, and receive a final decision from ABET. Programs then repeat this process every six years (Aft, 2002). Benefits of ABET accreditation include assurances that the program meets minimum standards and graduates are prepared for jobs (Aft, 2002).

As a part of accreditation and reaccreditation, ABET requires a self-study report (ABET, 2018b). This self-study report typically relies on faculty providing data and input on measuring student learning outcomes (ABET, 2018b). A program must summarize student performance and progress, which includes the process to establish and revise student learning outcomes (ABET, 2018b). Evidence can be provided both qualitatively and quantitatively (ABET, 2018b). The self-study report also discusses progress on continuous improvement (ABET, 2018b). However, as indicated by Astin

(2016), 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" (Astin, 2016).

The EC2000 provided general criteria requirements that apply to all accredited programs and program criteria, which are discipline specific (ABET, 2018a). Today's general criteria are similar to those detailed in the EC2000 criteria. The 2019-2020 EAC has seven general criteria for student outcomes (ABET, 2018a). These seven student outcomes in engineering tie closely to those needs indicated by employers of graduates, from technical to non-technical. The seven criteria for engineering baccalaureate degree programs must include the ability to solve engineering problems using sound principles of science, math, and engineering, produce solutions while considering impacts to public health, safety, and welfare and socioeconomic factors, effectively communicate, practice ethical and professional judgment for a variety of socioeconomic contexts, teamwork, engineering judgment from experimentation, and learn and apply new knowledge (ABET, 2018a).

The National Academy of Engineering reemphasized the technical and non-technical skills above in their Engineer of 2020 Project (National Academy of, 2004). The NAE put together a committee of individuals from academia and industry that hosted students and keynote presenters from large technological corporations that have a stake in the future of engineers. In 2002, this group worked through different scenarios of what the future engineer may need to address. Scenarios included the next scientific revolution, the biotechnology revolution, the natural world, and the influence of global changes. The committee provided a list of skills that the future engineer should be competent in. These skills were similar to the the EC2000 criteria and today's ABET general criteria.

To gain accreditation, engineering programs must show that students gain competence in the ABET general criteria, which are in addition to program specific criteria. These skills have been dubbed by some as "professional skills" that include both the technical and non-technical needs of engineering graduates (Chan et al., 2017). ABET now reviews programs based upon evaluating intellectual skillsets of graduates that includes a continuous improvement process (Prados et al., 2005). In other words, ABET accreditation is outcomes-based accreditation with an emphasis on continuous improvement of programs.

Similarly, at the institution accreditation level, there are criteria expected for learning outcomes. For example, the Higher Learning Commission (2019) requires that the general education of students provides for a broad knowledge base of intellectual concepts to allow for students to develop the necessary skills and attitudes that the institution believes college educated individuals should have.   The Council for the Advancement of Standards in Higher Education (2015) sets forth six broad categories for student learning and development outcomes. These six categories include knowledge acquisition, construction, integration and application, cognitive complexity, intrapersonal development, interpersonal competence, humanitarianism and civic engagement, and practical competence (C. f. t. A. o. S. i. H. Education, 2015). Simply put, there is a trend in higher education to see students succeed and be competent in professional skills, no matter their chosen profession.

Accreditation, at either level, provides substantial benefits to the specific program, institution, students, employers, and taxpayers (Aft, 2002). Accreditation, especially at the programmatic level, has moved toward outcomes-based assessment criteria (Duff, 2004). Outcomes assessment provides a means to determine (1) what is being done, (2) what is said is being done, and (3) what should be done (Duff, 2004). Outcomes assessment, as a part of accreditation, provides a systematic way of determining the effectiveness of the educational process (Duff, 2004). It is important to point out that outcomes assessment becomes most successful when everyone involved is fully vested in the process and there is continuous improvement woven throughout the process (Duff, 2004).

An example of the outcomes assessment model and integration of all aspects of a specific program is that of The American University in Cairo, which recently went through the start-up and full accreditation of the Construction Engineering Program using the Engineering Accreditation Commission (EAC) ABET criteria. This program had the advantage of completely developing their academic program through the outcomes assessment model required by ABET (Ezeldin, 2013).

The EC2000 provided general criteria requirements that apply to all accredited programs and program criteria, which are discipline specific (ABET, 2018a). The Construction Engineering Program at The American University in Cairo, since it was a brand new program, was able to tie the program's mission, objectives, and outcomes such that they all worked together (Ezeldin, 2013). Although The American University in Cairo only recently completed this process, it is apparent in the development of the program that everyone involved was vested in the outcomes assessment model required by ABET (Ezeldin, 2013).

The American University in Cairo had an advantage in developing its entire Construction Engineering Program around the outcomes assessment model; many existing programs under the ABET accreditation process had to transition to the newer criteria in EC2000. ABET accreditation shifted to outcomes assessment based upon employers of engineering graduates expressing the perceptions that graduates lacked skills in communication, team work, and nontechnical forces that influence engineering decisions (Prados et al., 2005). The general criteria that EC2000 requires for all accredited programs include both application of technical knowledge as well as the development of the students' skills in teamwork, ethics, communication, and life-long learning (ABET, 2018a; Prados et al., 2005).

EC2000 Impacts on Student-learning Outcomes

Based upon the multi-year study by Prados, Peterson, and Lattuca (2005), the data suggested that as programs transitioned to the new *criteria* there were improvements in engineering education. Volkwein, Lattuca, Harper, and Domingo (2007) provided further analysis of the original data, reaffirming that the application of the EC2000 criteria was working (Volkwein et al., 2007). Furthermore, the new criteria did not impact the overall program specific technical knowledge of graduates, though there could have been external influences contributing to the improvement in graduates (Volkwein et al., 2007).

From a short-term perspective, Volkwein et al. (2007) determined that the EC2000 criteria were working as expected after the first cycle of evaluations. They did admit that the EC2000 criteria may not be the only impact on engineering program changes and that there could be other external or internal influences (Volkwein et al., 2007). The improvements of moving engineering to an outcomes-based accreditation model are an incremental step in the right direction to ensure students are learning. However, given that the perceived skills gap persists, there is still more work to be done.

Additionally, given the aspect of continuous improvement in the accreditation model, many long-term effects may not be known yet. This is particularly true on the side of student learning. If engineering faculty fully buy into the continuous improvement process and the need to adapt their teaching style to meet the needs of their students, student gains in these programs could become more quantifiable.

Student Development and Learning

Before diving into assessing student learning outcomes, it is important to address student development and student learning theories. Undergraduate student development is a vast field of study. Therefore, only the Chickering and Reisser theory of development will be presented here as it is tailored to college student development and provides connections to the students' perceptions of their own experiences in development. Additionally, Kolb's Learning Theory, Felder and Silverman's Index of Learning Styles, and Perry's Model of Intellectual and Ethical Development are all common theories used in engineering education and will be discussed. Additionally, Baxter Magolda's Self-Authorship theory will be presented as it discusses the growth in one's identity.

Chickering and Reisser and Student Development

Arthur Chickering and Linda Reisser (1993) provide a useful lens to view college student development. Their theory includes seven vectors that are broad and conceptual in nature and permit educators the flexibility of interpretation and application within their own fields (Chickering, 1993). An important aspect of the seven vectors is its connections to the students' perceptions of their experiences in their own development (Chickering, 1993). The seven vectors include developing competence, managing emotions, moving through autonomy toward interdependence, developing mature interpersonal relationships, establishing identity, developing purpose, and developing integrity (Chickering, 1993). The seven vectors are described below and as shown in Figure 2.2.

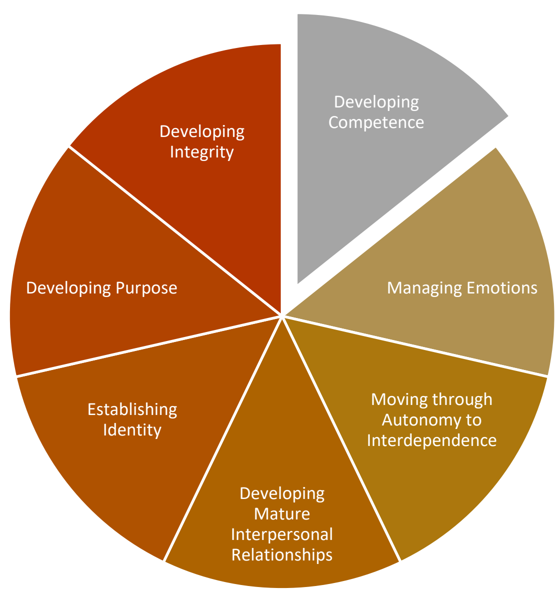

Figure 2.2. Chickering and Reisser's seven vectors of student development

Developing competence. Developing competence occurs in three main areas: intellectual, physical and manual skills, and interpersonal (Chickering, 1993). Intellectual competence has to do with the development of the mind, including advancing one's self to understand, scrutinize, and produce (Chickering, 1993), while physical and manual competence is developing one's physical capabilities and creating real products

(Chickering, 1993). Interpersonal skills relate to the ability to function within a relationship or group by fostering skills such as listening and communicating (Chickering, 1993).

Managing emotions. The vector of managing emotions is a college student's ability to balance the varying emotions that emerge during the college years (Chickering, 1993). Students must learn how to deal with all emotions, the good and the bad. Students develop along this vector as they increase their awareness and can accept and respond appropriately without impacting relationships (Chickering, 1993).

Moving through autonomy. Moving through autonomy toward interdependence is a vector that requires several things to occur. First, a student must break free from constant needs for reassurance (Chickering, 1993). Second, a student must develop the independent ability to think critically to solve problems and put plans of action into place (Chickering, 1993). Finally, the student must develop the form of autonomy that includes interdependence, or the capability to have true give-and-take relationships with peers (Chickering, 1993). As students move through this vector, a balance of independence and inclusion with others occurs (Chickering, 1993).

Developing mature interpersonal relationships. The vector of developing mature interpersonal relationships is growing in both in tolerance and intimacy. Students develop diversity of thought within the relationship as they begin to tolerate differences with others, avoiding stereotypes through increased awareness of various cultures and backgrounds as well as within personal relationships (Chickering, 1993). Increased intimacy comes from developing relationships beyond the superficial, narcissistic level to a deeper level of shared interdependence (Chickering, 1993).

Establishing identity. Establishing identity includes seven areas of growth for a student. These include comfort with one's own body and appearance, gender and sexuality, sense of self in varying contexts, life-style choices, responses to feedback, self-acceptance and esteem, and stability and integration (Chickering, 1993). As a student grows in these areas, it leads to an individual who is stable in his or her own self-worth and capabilities (Chickering, 1993).

Student development. Student development also includes developing purpose. To develop purpose, one must prioritize and bring together career aspirations and personal and family commitments (Chickering, 1993). As these values emerge for a student, the path for his or her purpose is clarified beyond going to college to get a good job (Chickering, 1993).

Integrity. The final vector Chickering and Reisser (1993) address is the student development of integrity. While closely related to the establishment of one's identity and purpose, integrity involves growing in the realm of values. Students begin to look beyond rigid beliefs to balancing their beliefs with those of other individuals (Chickering, 1993). Additionally, this results in a personalization of values while acknowledging other viewpoints; this effort culminates in the student's behavior matching the values they hold (Chickering, 1993).

Chickering and Reisser (1993) take the seven established vectors further in hypothesizing and providing support for the key areas that influence student development in college. The key areas include institutional objectives, institutional size, student-faculty relationships, curriculum, teaching, friendships and student communities, and student development programs (Chickering, 1993). Ultimately, whether they intend to or not, institutions of higher education provide for all these key areas. Each of these areas, depending on the implementation, can foster or hinder student development in the different vectors (Chickering, 1993).

Student Learning in Engineering

Woven throughout Chickering and Reisser's seven vectors of student development is student learning, whether that be the development of intellectual competencies or moving through autonomy toward interdependence. Since the inception of higher education, student learning has been a key issue (Goodchild, 2002), and the engineering disciplines are no exception. Astin (2016) explains the mission of higher education is "to equip them with appropriate knowledge, skills, and other personal qualities, that enable them to perform critical functions in the society and be responsible citizens" (p. 37). This sentiment matches Chickering and Reisser's vectors of student development. Consequently, student learning and assessment of student learning outcomes within engineering should be researched to ensure that higher education institutions and programs are equipping graduates with the necessary skills to be fully-functioning and productive members of society.

Student learning and student learning outcomes go together and commonly appear as a part of accreditation criteria, including criteria detailed by ABET for engineering programs. Before being able to gain an understanding of the student learning outcomes achieved as a part of the accreditation process, there must be an understanding of the way students learn in the higher education environment. Kolb's learning styles, Felder and Silverman model of learning styles, and Perry's model of intellectual will be presented here.

Kolb's Learning Theory

Learning through experience has long been a key component in higher education, particularly engineering education (Harrisberger & Others, 1976). John Dewey (1938) based his criteria of experience on two main ideas: continuity and interaction. The idea of continuity is that each experience is built on past experiences and then provides for future experiences (Dewey, 1938). Interaction within the educational context is taking into account both the objective and internal conditions of a given experience (Dewey, 1938).

Based upon David Kolb's observations and research by John Dewey, Kurt Lewin, and Jean Paiget, Kolb's Learning Theory emerged (1984). David Kolb (1984) defines experiential learning as "the process whereby knowledge is created through the transformation of experience" (p. 38). Given his definition of experiential learning, Kolb's (1984) learning model consists of a four-stage cycle: concrete experience, reflective observation, abstract conceptualization, and active experimentation. Each of these stages is considered a learning mode (Kolb, 1984). The cycle allows an individual to move through the stages during the learning process (Kolb, 1984).

The concrete experience stage consists of a new experience or a repeated experience in a new way (Kolb, 1984; McLeod, 2013). In the next stage, reflective observation, an individual reflects on the recent experience (Kolb, 1984; McLeod, 2013). Once an individual is able to draw a conclusion from the experience, he or she has moved into abstract conceptualization (Kolb, 1984; McLeod, 2013). The final stage comes when a person can test what he or she learned through active experimentation (Kolb, 1984; McLeod, 2013). Kolb (1984) indicates that all four stages of the cycle are essential in learning. The cycle repeats itself in a spiral type structure, always building on previous experiences (Kolb, 1984).

Kolb's Learning Style Inventory. Kolb (1984) overlays the learning cycle with individuals' learning styles as illustrated in Figure 2.3. Kolb's Learning Style Inventory has four learning styles: convergent, divergent, assimilation, and accommodation. Each learning style relates to two of the stages in the learning cycle and falls within a quadrant on the cross axis of a processing continuum and perception continuum. The convergent learning style associates with abstract conceptualization and active experimentation. The divergent learning style emphasizes concrete experience and reflective observation. The assimilation learning style utilizes abstract conceptualization and reflective observation. The accommodative learning style relies on concrete experience and active experimentation (Kolb, 1984).

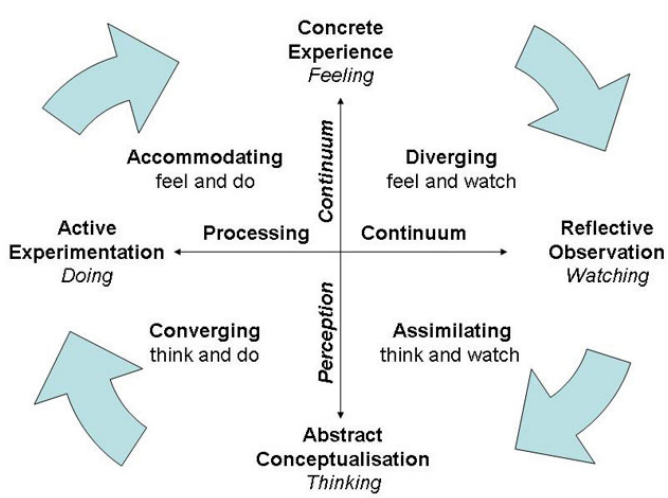

Figure 2.3. Kolb's learning styles and experiential learning cycle (McLeod, 2013).

Felder and Silverman's Index of Learning Styles

Felder and Silverman (1988) built upon Kolb's learning styles. Felder and Silverman's Index of Learning Styles consists of four main categories: sensing or intuition, visual or verbal, active or reflective, and sequentially or globally. The first two categories are how a student receives information and the latter two categories are how a student processes the information (Felder & Silverman, 1988). This enables faculty to have a better understanding of a student's learning style, beyond just experiential learning. All learners fall into one of the two styles in each category. For example, a student could be an active, sensing, visual, sequential learner. To understand how a student learns, each of the categories should to be considered individually.

Students show preference for the type of information received and are considered either sensing or intuitive. Sensing students perceive information better through external sights or sounds. Intuitive students perceive information better internally via insights. Students also naturally divide between being either visual or verbal, which is how they receive external information. Visual learners prefer pictures or diagrams while verbal learners prefer audible language. These two categories of perception and input reflect the first step in the learning process of receiving information (Felder & Silverman, 1988).

The second step of the Felder and Silverman (1988) learning process is how the student processes and understands the information they received. First, a student must process the information, and does so either actively or reflectively. Active learners prefer physical activity or discussion while reflective learners prefer self-analysis. After processing the information, a student works toward understanding the information, either sequentially or globally. Sequential learning is in steps and global learning is a holistic approach (Felder & Silverman, 1988).

It should be noted that there was previously an additional category placing students into either inductive or deductive means of organization of information. However, Felder later removed this category as it was found that students would say they prefer the deductive approach, but, an inductive presentation enables students to progress through the reception and processing of information.

The active or reflective category is derived directly from Kolb's Learning Theory of experiential learning (Felder & Silverman, 1988). Felder and Brent (2005) provide the type of instructors that works best with the four learning styles by Kolb: convergent, divergent, assimilation, and accommodation. Teaching to a convergent learner, the instructor should act as a coach. Teaching to a divergent learner, the instructor should act as a motivator. Teaching to an assimilation learner, the instructor should act as the expert. Teaching to an accommodation learner, the instructor should ask open-ended questions and utilize problem-based learning (Felder & Brent, 2005).

For engineering disciplines, the typical teaching pedagogy only fulfills the needs of the assimilation learner. Felder and Brent (2005) recommend that the most effective teaching style, according to Kolb's model, is to teach around the cycle by motivating new topics, presenting basic information on a given topic, practicing within the topic, and providing means of applying the topic.

Felder and Silverman (1988) were able to build upon Kolb's learning styles by adding the sensing/intuition, visual/verbal, and sequentially/globally categories. This enables educators to have a holistic approach of a student's learning style. Each of the four categories of student learning described by Felder and Silverman (1988) correspond with a teaching style. The category of student perception will rely on the content the teacher relays. The content will be either concrete or abstract. The presentation of the content will be either visual or verbal. Faculty rely heavily upon student participation being either active or passive, which corresponds to the students' learning being active or reflective in processing information. Finally, the faculty will have their own perspective on whether material should be presented sequentially or globally.

Similar to what was found by Felder and Brent in the Kolb model, there is a mismatch in learning and teaching style. According to Ruutmann and Kipper (2013), most engineering students fall under the sensing, visual, active, and sequential. However, most engineering educators use teaching methods best received by intuitive, verbal, passive, and sequential learners (Ruutmann & Kipper, 2013).

Overall, research sheds light on the kinds of innovative pedagogical practices available for implemention for engineering students. However, their implemention warrants research to answer the question: How do those in higher education understand how well the student is obtaining these learning outcomes, particularly the generic skills that may not be assessed with a letter grade at the end of the course or program?

Perry's Model of Intellectual and Ethical Development.

Perry's Model of Intellectual and Ethical Development has been used to help evaluate student-learning gains. William Perry's model is based on a series of nine positions (Perry, 1999). These positions represent a college student's intellectual and ethical development through the lens of how college students view the world (Finster, 1989; Perry, 1999).

Positions 1 and 2 are under the category of dualism, where students see things as right or wrong and truth is absolute. Positions 3 and 4 are considered to be multiplicity, where uncertainties are seen (Finster, 1989). Positions 5 and 6 are relativism, meaning that knowledge is situational and can be relative. The remaining positions, 7 through 9, are commitment to relativism, with the important distinction that the student must commit to the differing opinions (or truths). Once the commitment is made, that is when true ethical and identity development can be made (Finster, 1989).

According to Finster (1989), it is positions 2 through 5 that apply to pedagogy. Pedagogy, in turn, results in student learning and learning outcomes. Therefore, it can be assumed that as students' progress through the positions in Perry's model they make learning gains. Perry (1999) suggests that the concept of critical thinking emerges by position 4. Critical thinking and problem solving skills are important traits of engineering graduates and are often sought by employers (Prados et al., 2005).

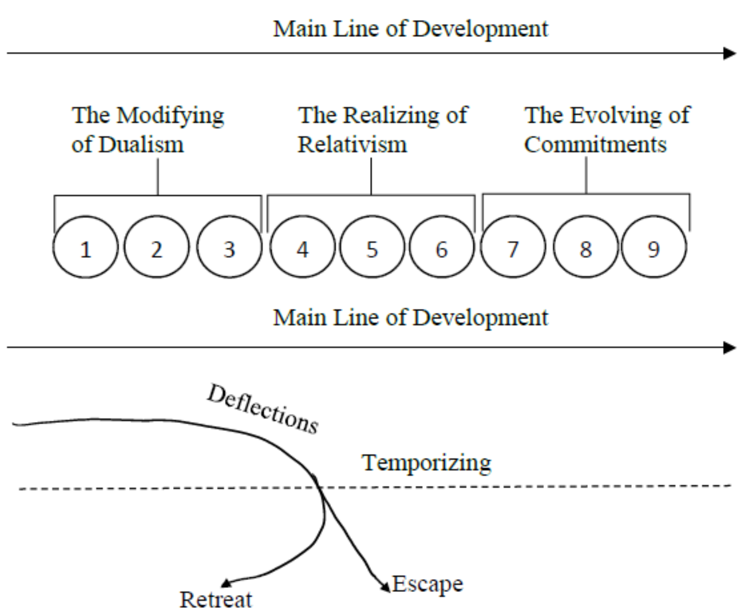

Figure 2.4. Perry's schematic representation of development (Perry, 1999, p. 65)

An important aspect to review in Perry's model is the concept of deflection. According to Perry (1999), an individual's development may be suspended or even regressed at any of the above positions. There are three main types of deflection: temporizing, retreat, and escape. Temporizing is considered a pause in growth. Retreat is considered to be regression in growth. Escape is the movement toward denying or rejecting the implications for growth (Perry, 1999).

Self-Authorship

Another theory to consider in student development is that of Baxter Magolda's Self-Authorship. This theory consists of three elements in which students are able to define their beliefs, identity, and social relations to be able to have the developmental capacity to handle the challenges seen in adult life (Baxter Magolda, 2008). The three components to gain self-authorship include trusting the internal voice, building an internal foundation, and securing internal commitments (Baxter Magolda, 2008).

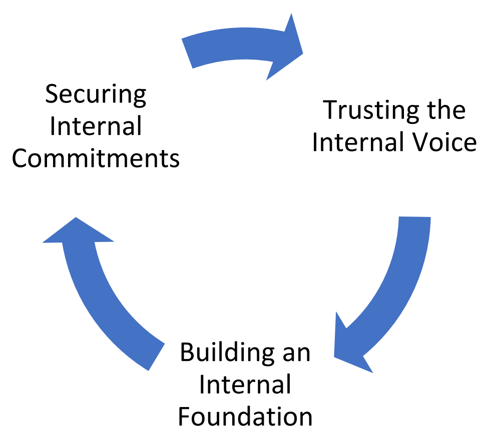

Figure 2.5. Self-Authorship Cycle (Baxter Magolda, 2008)

Trusting the internal voice involves the development of that voice to make decisions on beliefs, identity, and social relations. Building an internal foundation involves using the internal voice to build a belief system; and it aids in solidifying that belief system. The third component of securing internal commitments is where the belief system is strengthened. These components are considered cyclical and continuously build on one another as an individual makes meaning of themselves as shown in Figure 2.5 (Baxter Magolda, 2008). The concept of self-authorship may provide insight as to why students perceive themselves at a certain level of competency of a generic skill.

Engineering Student Learning Outcomes and the Skills Gap

Research from the Carnegie Foundation, Stanford Research Center, and Harvard University concluded that 85% of job success comes from the generic soft skills (Mann, 1918). In 1976, Harrisberger and Others, as a part of the American Society of Engineering Educators, expressed that a experiential learning program should support the following: "problem solving skills, interpersonal awareness, creative expression, communication skills, technical skills, self confidence [sic] building, computation skills, engineering fundamentals, organizational skills, leadership skills, planning skills, professional ethics, engineering judgment" (p. 7). In the late 1980s, the clash between higher education engineering programs and employers came to light. Feedback from employers included the need for engineers with "strong technical capability… skills in communication and persuasion, an ability to lead and work effectively as part of a team, an understanding of the nontechnical forces that profoundly affect engineering decisions, and a commitment to lifelong learning" (Prados et al., 2005, p. 168).

The transition to the EC2000 criteria had much to do with addressing the industry skills gap. Prados, Peterson, and Lattuca (2005) indicated that engineering graduates had the necessary technical skills but lacked in the skills needed to develop and innovate technology. However, even with the transition to the new outcomes-based accreditation criteria, there are recent studies still showing the existence of a skills gap of graduates.

A study performed by Chegg (*Bridge that gap*, 2013) concluded that there continues to be something missing at the intersection of higher education programs and workforce preparedness. The study showed that there is disconnect in what employers are seeking and what skills graduates believe they possess. For example, hiring managers thought that graduates lacked communication and teamwork skills. Although those hiring graduates in Science, Technology, Engineering, and Mathematics (STEM) fields versus non-STEM fields indicated those students were better prepared, there was still a gap (*Bridge that gap*, 2013).

Feutz and Zinser (2012) further emphasized this statement by pointing to the instance of when graduates of a Career and Technical Education program indicated that the communication course that they took while in school benefited them the most upon graduation. These graduates also indicated a project management driven curriculum could better prepare them for the workforce (Feutz & Zinser, 2012).

In today's work environment, employers are not willing to hire graduates that will not add value to the productivity of the organization. According to Ejiwale (2014), graduates lack the skill of how to learn on the job and how to communicate effectively, in both the written and verbal context. However, is it just up to a specific program or higher education institution to better prepare students for the workforce? Ejiwale (2014) indicates that all stakeholders, including students, educators, and the hiring industry, need to take part in addressing the skills gap issue.

Students need to take initiative and responsibility in recognizing what employers in their field want. Educators, at both the K-12 level and higher education, must play a role in transitioning students into college and then into the workforce. Industry should be included as a part of the higher education curriculum development. Industry must define to those in higher education what their specific needs are in a given field (Ejiwale, 2014). This employer emphasis reaffirms the importance in outcomes assessment criteria and the need to have all stakeholders fully vested in the process (Duff, 2004).

Employer involvement in training and education is not new. Newfield (2003) discusses how by 1900, companies were creating introductory and supplemental training courses for new college graduates to "transform engineers from soloists to team performers" (p. 348). According to Ejiwale (2014), many companies do not want the expense to train new graduates and indicate that the purpose of higher education is to provide students with a skill set. However, many graduates still need additional training upon graduation (Ejiwale, 2014).

The skills gap is even relevant in experiential learning, depending upon the individual's learning style. David Kolb reviewed a study completed on managers that reported their undergraduate major. Based upon the reported majors, those in STEM fields fell under either the convergent or assimilation learning styles (Kolb, 1984). He also noted that those individuals that studied basic academic disciplines (i.e. mathematics, chemistry, physics) were on the more reflective end of the spectrum as compared to those in fields considered a professional undergraduate major, such as engineering or nursing. Kolb concludes there is a period of transition for those in the basic academic disciplines from higher education to industry that individuals must also shift from reflective to active learning (Kolb, 1984). It is possible to conclude that this period of transition between reflective and active learning is a "skills gap".

Engineering Student Learning Outcomes and Current Assessment Strategies

From the beginning of higher education to today, much has changed in the understanding of how students learn and how to evaluate learning. John Dewey is known as one of the great early educational philosophers. Dewey lived during a time when the educational approach was focused on delivering knowledge to the student and not on student discovery. Dewey thought that teachers needed to take into account student experience and needs (Neill, 2005).

However, current assessment practices designed by faculty and the traditional teaching approach may overlook nuances of actual student learning (Astin, 2016). It is the assessment of student learning that indicates what students are actually learning. Faculty must measure student-learning outcomes through assessment. This assessment is formalized through the accreditation process. Accreditation, thus student-learning outcomes, provides the accountability and standardization to the higher education system (Goodchild, 2002).

As indicated earlier, faculty are charged to assess their students' learning, particularly through the accreditation requirement. Since the inception of the EC2000 criteria, accredited engineering programs have been working toward finding appropriate methods to assess student learning outcomes. Ewell (1998) reviewed the national trends of student learning assessment and gave recommendations on the implementation of assessment programs that emphasize student learning outcomes. In particular, assessment has been trending from standardized tests or instruments to performance-based assessments. This includes building examinations or instruments that are specifically designed to measure a set of items across a group rather than the individual.

There are several ways that student learning outcomes in engineering have been assessed. This includes faculty assessments of student development and learning. Faculty have attempted to assess student development in different ways. For example, Perry's Model of Intellectual and Ethical Development or Kolb's Learning Theory, have both been used in engineering to assess student learning or development. Additionally, various quantitative instruments have been used to assess the students' perspective of their learning to provide for measures of group-level performance.

Survey Instrument Assessment

A study conducted in 2001 utilized the Classroom Activities and Outcomes Survey instrument to have students self assess progress made based upon a particular course (Terenzini, Cabrera, Colbeck, Parente, & Bjorklund, 2001). Comparisons were made between students enrolled in active or collaborative learning courses and students within traditional lecture methods courses (Terenzini et al., 2001). Even when controlled for pre-course characteristics, students reported higher gains in the active or collaborative learning courses with regard to the seven EC2000 learning outcomes being studied (Terenzini et al., 2001).

Melguizo and Wainer (2016) utilized data from a college exit examination employed in Brazil, Exame Nacional de Desmpenho dos Estudantes (ENADE). Of particular interest, the ENADE exam was also given to incoming freshmen, which allowed for the opportunity to understand the gains in both general and specific knowledge areas by calculating effect sizes (Melguizo & Wainer, 2016). Within the

Science, Technology, Engineering, and Math programs, students were found to gain 0.1 to 0.2 standard deviations in general knowledge and 0.5 to 1.0 standard deviations in specific knowledge (Melguizo & Wainer, 2016). The authors indicated that the limitations of this descriptive study included not controlling for previous academic preparation, program or college student selection criteria, and only partially accommodating for non-random attrition (Melguizo & Wainer, 2016). However, the study provided useful insight in that students gained in both general and field-specific knowledge during their time in higher education (Melguizo & Wainer, 2016).

Scholl and Olsen (2014) took the assessment process a step further in measuring the student learning outcomes of a program through the use of the Student Assessment of Learning Gains (SALG). They found a significant increase indicated by students in their development of research and evaluation skills as well as their overall perception of integration of learning (Scholl & Olsen, 2014). Scholl and Olsen (2014) concluded that the SALG instrument is an effective way to measure student learning outcomes and could be further tested for usefulness in accreditation outcomes assessment.

Experiential Learning Assessment

As indicted previously, experiential learning is a useful approach in engineering education. Experiential learning is executed in a variety of ways, from service learning to laboratory experiments to project-based learning. Kolb's Learning Theory is one useful approach for engineering education, given its emphasis on experiential learning. Chan (2012) found that engineering students that participated in service projects gained valuable experiences in their learning process that included applying skills beyond technical skills, such as problem solving skills. Chan observed that the participants benefited from experiential learning. In relation to Kolb's learning theory, the students had concrete experiences, which in turn allowed for observation and reflection and then the formation of new concepts (abstract conceptualization), and then permitted for experimentation. Chan indicated that the cycle was repetitive in nature, based upon student responses during the focus groups where students provided insight about having to redesign approaches multiple times to make the project work in the real world environment. Another service project participant indicated that the generic skills associated with the ABET criteria described earlier, such as problem solving and teamwork, were instrumental in the service projects success (Chan, 2012).

Another valuable pedagogical approach to gaining the generic skills that employers require, is either problem-based or project-based learning. Again, stemming from Kolb's Learning Theory, Mills and Treagust (2003) provide insight on the impact of using either problem-based or project-based learning in lieu of the traditional lecture approach in the classroom. The case studies provided emphasis on how the problem-based or project-based courses helped to enable students with skills such as communication and teamwork, as well as with understanding of the impacts and applications of engineering (J. E. Mills & Treagust, 2003).

Pavelich and Moore (1996) evaluated student learning through Perry's Model of Intellectual and Ethical Development. Within this study, students were followed through a project-based curriculum. The study looked at students' gain in complex thinking and decision making. The researchers found that students worked their way through the stages in the model, but not as quickly as what industry wanted (Pavelich & Moore,

1996) Later, Pavelich (1996), came to the same conclusion on the project-based curriculum impact on developing students in attaining that higher level of thinking.

As part of the discussion on experiential learning and pedagogy, it is important to look at the role of the laboratory. Laboratories also provide an educational approach beyond the traditional chalk and talk found in classrooms. Laboratories have many different meanings, ranging from hands-on labs, simulation labs, to observations labs. Technology and distance education have impacted the use of laboratories in the engineering educational setting. Feisel and Rosa (2005) concluded that laboratory activities need to have fundamental objectives as well as a means to assess their outcomes.

As described above, over the years there have been a variety of approaches to assess student learning outcomes. Although assessments add value to student learning and learning outcome assessment, they can be limited. When Perry or Kolb's models are utilized to assess student learning outcomes, they are typically for a particular course, learning experience (such as service learning), or assignment (such as project based learning). Survey instruments are many times utilized within a particular course or assignment. Few studies attempt to assess student learning outcomes across the ABET criteria all at once.

Engineering Students and Individual Demographics

The previous section discussed the different methods that have been used to assess student learning outcomes. The following section will discuss similarities and differences previously found between groupings of engineering students based on individual demographics. These groupings include engineering students' academic grade level, gender, ethnicity, and previous engineering experiences.

Engineering Student Learning Outcomes and Academic Grade Level

Lehre, Hansen, Lehre, and Laake (2014) did a comparative study of student learning outcomes prior to and after the 2003 Quality Reform in the Norwegian Higher Education system. In brief, the 2003 Quality Reform changed the teaching model and student assessment. A key component of the reform was a shift from a teacher perspective model to a student-centered system, allowing for increased student feedback. The researchers found that after the reform, older students performed better on examinations than younger students, as compared to younger students out-performing older students prior to the reform (Lehre et al., 2014).

Chesbrough (2011) found that there was a statistically significant difference in students' self-reported learning from service based upon the independent variable of year in school. The learning outcomes that were considered significant based on year in school included learning about myself, leadership, relationships, organizations, and community (Chesbrough, 2011).

Engineering Student Learning Outcomes and Gender

Lehre, Hansen, Lehre, and Laake (2014) 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 (Lehre et al., 2014).

However, Ro and Loya (2015) 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 males. 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 (Ro & Knight, 2016). 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 (Ro & Knight, 2016).

Chesbrough (2011) 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 (Chesbrough, 2011).

Engineering Student Learning Outcomes and Ethnicity

Using the intersectional approach to gender, Ro and Lova (2015) 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 (Ro & Loya, 2015).

Engineering Student Learning Outcomes and Pre-Graduation Engineering Experiences

Daniel and Mishra (2017) studied student learning outcomes associated with affective, behavior, and content (ABC) outcomes after students participated in a Science, Technology, Engineering, and Mathematics-based International Service Learning (ISL) course. The researchers found that students reported significant gains in civic attitudes and skills, as well as increased likelihood for students to want to participate in future service learning opportunities (Daniel & Mishra, 2017).

Litchfield, Javernick-Will, and Maul (2016) performed a study on the development of both technical skills and generic skills of engineers. The study was aimed at understanding self-reported learning outcomes and if they differed between those students and practicing engineers that experienced engineering service activities, versus those that did not experience these activities. This mix-methods study provided valuable insight on engineering experiences in learning. The participants involved in engineering service-learning activities reported statistically significant higher levels of generic skills. During the qualitative portion, students reported communication, work ethic and teamwork as being important parts of the service activities. Furthermore, participants indicated that they had higher levels of generic skills, which were attributed to some of the engineering service activities (Litchfield et al., 2016).

Chesbrough (2011) found, when looking at the number of hours committed to service learning activities by a student, that the higher the number of hours the higher the level of self-reported learning outcomes. All items asked regarding a student's learning from service were considered statistically significant. These items included learning about others, myself, leadership, relationships, organizations, people, justice, caring, social issues, community, duty, and love (Chesbrough, 2011).

Summary

In this chapter, engineering student learning, student learning outcomes, assessment, and continuous improvement was presented. This included details and previous research on commonly accepted models of continuous improvement, the role of accreditation in accountability, ABET’s role in engineering education, student development and learning theories, industry skills gap, current assessment strategies, and demographic impacts on learning outcomes. The following chapter will present the methodology for researching student perceptions of their generic skills competencies.

CHAPTER III

METHODOLOGY

The previous chapters provided the context for the need to research students' perspectives of their self-competencies of generic skills. This chapter describes the research design that was used to examine how students perceive self-competency levels in their generic skills area. To accomplish this goal, the study used the Generic Skills Perception Questionnaire (GSPQ). The following sections present the general research perspective, the research context, the research participants, instrumentation, procedures and data collection, data analysis, and summary.

The General Research Perspective

This study utilized a quantitative approach to answer the research questions. A quantitative approach is appropriate when data are collected and analyzed to describe or explain a given phenomenon (G. E. Mills & Gay, 2016). In this dissertation, the data collected were analyzed to describe and explain student perceptions of their generic skills competencies. The following paragraphs describe this study's epistemology, theoretical perspective, and research approach.

Epistemology and Theoretical Perspective

The approach for this study was from an epistemological viewpoint of objectivism and, subsequently, post-positivism as its theoretical perspective (Crotty, 1998). An epistemology, or as Creswell (2014) calls it, a worldview, is the "general philosophical orientation about the world and the nature of research that a researcher brings to a study" (p. 6). Objectivism is an approach that assumes that reality exists separate from any consciousness. The goal of objectivism is to discover the objective truth (Crotty, 1998).

Crotty (1998) describes one's theoretical perspective as the "assumptions brought to the research task and reflected in the methodology …" (p. 7). Post-positivism understands that there is a reality outside a given human experience and that this reality can be almost determined through the scientific method. However, it is recognized that absolute reality can never be reached. Post-positivism researchers will separate themselves from the research, as much as feasibly possible, with controls as well as the acknowledgement that there are biases. Generalizations are the goal of the research, with the understanding that reality can only be approximated. In conjunction with never being able to determine an absolute reality, the hypotheses are not verified, but found to be mostly true (Stage & Manning, 2016).

Research Approach

This quantitative study specifically used a cross-sectional survey research design. According to Creswell (2014), survey research design provides a quantitative description of trends or opinions of a given population by studying a sample of that population. Within this research study, students provided their perceptions of their self-competency of generic skills. This approach necessitated the use of survey research via a questionnaire and subsequently, the analysis of the data. The study was considered cross-sectional because it collected data from individuals at a single point in time (G. E. Mills & Gay, 2016).

The Research Context

Higher education is constantly being pushed to ensure quality within the many undergraduate programs offered. Engineering programs are no exception to this outside pressure. ABET is one of the lead program specific accreditors for undergraduate engineering programs across the United States and even around the world. ABET's focus for accreditation is on student outcomes, self-assessment, and continuous improvement.

The student outcomes required by ABET are commonly referred to as generic skills, or a skill set that is not discipline specific (Bennett et al., 1999). These generic skills, or ABET student outcomes, include examples such as problem solving, communication, teamwork, and critical thinking. Current assessment strategies, however, are typically limited to either the viewpoint of the faculty or hiring industry. Limited assessment strategies include the student as a key stakeholder to ensure continuous improvement of the engineering program. A key component to the success of an outcomes based assessment is that all the stakeholders are involved in the process (Duff, 2004).

Therefore, because the student needs to attain these outcomes, it becomes imperative to gain an understanding of their perceptions of their competencies of these generic skills. Obtaining the students' perception of their levels of competency of all the desired student outcomes, or generic skills, could provide valuable insight into students' development of these skills throughout undergraduate engineering programs, enabling a further understanding of what is needed for the continuous improvement process. The following section describes the purpose of the research study, research questions, hypotheses, and variables.

Purpose of the Study

The purpose of this study was to examine undergraduate engineering students' perceptions of their generic skills competencies across academic level, pre-graduation engineering experiences, and individual demographics at a research university located in the Midwest. The engineering programs associated with this study were 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 inquiry.

The overarching research question was:

What are undergraduate engineering students' perceptions of their competency levels for generic skills at a Midwest research university?

The following sub-questions further guided this study:

1. Are there mean differences across academic grade level when the GSPQ is administered to undergraduate engineering students at a Midwest research university?

2. Are there mean differences across academic grade level for undergraduate engineering students who had pre-graduation engineering experiences, as compared to undergraduate engineering students who did not have pre-graduation engineering experiences, when the GSPQ is administered to undergraduate engineering students at a Midwest research university?
3. Are there mean differences in gender across academic grade level when the GSPQ is administered to undergraduate engineering students?
4. 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?

Research Hypotheses

The following are the research hypotheses utilized for this study.

1. There will be mean differences for undergraduate engineering students' generic skill competencies across academic grade level at a research university in the Midwest.
2. Students with pre-graduation engineering experiences will score significantly higher on measures of generic skills competencies across academic grade levels at a research university in the Midwest.
3. There will be mean differences for students' generic skill competencies across gender across academic grade levels at a research university in the Midwest.
4. There will be mean differences for students' generic skill competencies across majority race/ethnicity and minority race/ethnicities across academic grade levels at a research university in the Midwest.

Variables

Table 3.1 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.

Table 3.1

Variable Description Table

Variable	Type	Research Question	Analysis
GSPQ Scores	Dependent	1, 2, 3, & 4	
Academic Grade Level	Independent	1, 2, 3, & 4	One-way ANOVA
Pre-Graduation Engineering Experiences	Independent	2	Two-way ANOVA
Gender	Independent	3	Two-way ANOVA
Ethnicity	Independent	4	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. This was considered a purposive sampling method, because the criteria were deliberately set to select the sample population (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 (see Appendix B for email text). 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. Written email permission was gained from the author to utilize the instrument (see Appendix A). 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 (Chan et al., 2017).

The 12 domains include interpersonal skills, teamwork skills, communication skills, problem-solving skills, critical thinking, self-management, professional effectiveness, adaptability skills, information literacy, leadership, academic/learning skills, and community and citizenship knowledge. Drawing from these 12 domains, the developers of the instrument designed a questionnaire to aid in understanding students' perceived level of self-competence within each of the domains (Chan et al., 2017).

In addition to the 35 generic skill items within the instrument, there was demographic questions to which students are asked to respond. The demographic responses included gender, age, ethnicity, country of origin, program of studies, number of credit hours earned, and any pre-graduation engineering experiences. The demographic questions included those asked by the developers of the instrument as well as added demographic questions for credit hours earned and pre-graduation engineering experiences. The researcher ran different analyses of the various demographics to answer the research questions. Gathering the different demographics facilitated different analyses to answer the research questions. Although there were demographics beyond what was needed for this particular study, the additional demographics will serve for future research as well as comparisons to the original development and validation of the instrument.

Reliability and Validity

To reduce bias, Chan, Zhao, and Luk (2017) utilized the 12 domains to divide each generic skill into three to eight items. The individual response items were developed by reviewing existing questionnaires, empirical research, and discussions with engineering researchers and faculty (Chan et al., 2017). To determine the reliability and validity of the developed instrument, Chan et al. (2017) conducted a pilot study that included 1,241 first-year engineering students. With the data from the pilot study, the researchers were able to complete factor analysis on the instrument. Exploratory factor analysis (EFA) using Promax and an oblique rotation produced an eight factor solution accounting for 58.16% of the variance (Chan et al., 2017). Confirmatory factor analysis (CFA) was completed to validate the items and internal structure. The CFA suggested a good fit with the eight factor generic skill scales (Chan et al., 2017). The EFA and the CFA provided for eight factors. The eight factors were:

Factor 1: Academic and Problem-Solving Skills

Factor 2: Interpersonal Skills

Factor 3: Community and Citizenship Knowledge

Factor 4: Leadership Skills

Factor 5: Professional Effectiveness

Factor 6: Information and Communication Literacy

Factor 7: Critical Thinking

Factor 8: Self-Management Skills (Chan et al., 2017)

The internal consistency, or reliability, of the internal structure of the items in the instrument was assessed by Cronbach's alpha, concluding moderate to high consistency (Chan et al., 2017). The internal structures of the items were also analyzed using principal component analysis resulting in an eigenvalue greater than 1 for each one-factor solution, with the total variance ranging from 44.45% to 74.46%. At this time, the GSPQ has not been used by anyone beyond the original developers. The developers suggested the instrument could be used in different cultural contexts, although the original study was conducted only in Hong Kong (Chan et al., 2017). Furthermore, additional data on a cross-section of engineering students could provide more information because the original study was done on incoming freshmen (Chan et al., 2017).

Procedures and Data Collection

The researcher obtained approval for the study from the Institutional Review Board at Oklahoma State University. The researcher also obtained the necessary approvals from the research site's Institutional Review Board. The students selected as the sample population received an email inviting them to participate in the survey. The email contained a hyperlink to the Qualtrics site housing the survey. A follow-up email was sent approximately one week after the initial distribution, with an additional follow up email at the beginning of the third week. A final reminder email was sent in the final days of the survey. This permitted the survey to remain open for three weeks. A copy of the invitation email and follow-up emails are located in Appendix B. This method of multiple contacts to encourage survey responses is consistent with the Tailored Design Method developed by Don A. Dillman (2007). Within the Qualtrics survey, the participant reviewed the research consent prior to beginning the survey. The survey, with 35 Likert scale items and seven demographic questions, was expected to take less than 15 minutes to complete. A copy of the survey instrument is located within Appendix C. Once completed, the record of participant responses was held within Qualtrics and accessed only by the researcher. The data were uploaded and analyzed using SPSS.

Data Analysis

The data were collected from the Qualtrics survey platform. All responses were held within the Qualtrics program and accessed only by the researcher. 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 (Salkind, 2017). Descriptive statistics, such as mean, standard deviation, frequency, and ranges, were used for data grouping and data entry errors or omissions.

Inferential statistics aided in making inferences from a sample population (Salkind, 2017). Inferential statistics were used to explore the relationships between the variables. Specifically, to answer the research questions, both one-way and two-way analysis of variances (ANOVAs) were utilized. ANOVA was a statistical analysis approach used when the one factor being explored had more than two levels. One-way ANOVA was used when there was only one factor that created groupings. Two-way ANOVA was used when there were two factors that create groupings when looking at a single treatment. This is also referred to as factorial analysis of variance (Salkind, 2017).

For research question 1 – are there mean differences across academic grade level when the GSPQ is administered to undergraduate engineering students – one-way ANOVAs was employed to examine the group means of academic grade level. Academic grade level as defined as freshmen (0-29 credit hours earned), sophomore (30-59 credit hours earned), junior (60-89 credit hours earned), or senior (90+ credit hours earned). The group means of the GSPQ scores were compared across academic grade level. ANOVA was used because there were more than two groups and these groups were being compared according to their means (Salkind, 2017).

Research question 2 – are there mean differences across academic grade level for undergraduate engineering students who had pre-graduation engineering experiences as compared to undergraduate engineering students who did not have pre-graduation engineering experiences when the GSPQ is administered to undergraduate engineering students – was analyzed using 2-way ANOVA. The group means of pre-graduation engineering experience status (either the student had an experience or did not have an experience), were examined to determine if there were differences across academic grade level. This analysis permitted the mean scores of the GSPQ scores for students without pre-graduation engineering experiences to be compared to students with pre-graduation engineering experiences across the different academic grade levels. For the purpose of this study, pre-graduation engineering experiences were defined as activities such as service learning, internships, or co-ops.

Research questions 3 and 4 – 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 and 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.

Summary

This chapter described the methodology that was used to gather and subsequently analyze data to answer the proposed research questions. Specifically, this chapter addressed the general research perspective, the research context, the research participants, instrumentation, procedures and data collection, and data analysis. The following chapter will present the findings of this study.

CHAPTER IV

FINDINGS

The purpose of this study was to examine undergraduate engineering students' perceptions of their generic skills competencies across academic grade level, pre-graduation engineering experiences, and individual demographics at a research university located in the Midwest. This study was guided by the following research questions.

1. Are there mean differences across academic grade level when the GSPQ is administered to undergraduate engineering students at a Midwest research university?
2. Are there mean differences across academic grade level for undergraduate engineering students who had pre-graduation engineering experiences, as compared to undergraduate engineering students who did not have pre-graduation engineering experiences, when the GSPQ is administered to undergraduate engineering students at a Midwest research university?
3. Are there mean differences in gender across academic grade level when the GSPQ is administered to undergraduate engineering students?
4. 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?

Quantitative data analysis techniques, including descriptive statistics, and analysis of variance (ANOVA), were used to answer the above questions. The findings are provided in the following sections. First, an overall discussion of the sample will be provided. This includes how the data were cleaned for analysis, as well as a review of the reliability and fit of the model. Then, each research question will be addressed individually with the pertinent data provided to examine and test the hypotheses.

Sample Analysis

This study gathered demographics and generic skills competency level data from declared engineering majors at a research university located in the Midwest. The original data contained 177 responses. However, upon review of the data, there were 19 responses in which the respondent opened the survey but then did not answer any questions within the survey. As such, those responses were deleted. After deleting the empty responses, this left 158 responses. Any survey response that was partially completed was retained and any missing item response was treated as missing data within the analysis. Table 4.1 shows the descriptive statistics (number of responses, mean, and standard deviation) for each of the item responses.

Table 4.1

Descriptive Statistics by Item

Item	N	Mean	Standard Deviation
Academic and Problem-Solving Skills			
Design and conduct experiments	157	3.78	.765
Analyze and interpret data from experiments	157	3.98	.880
Identify and solve engineering problems	157	4.04	.808
Possess IT skills	156	3.40	.934

Apply knowledge of mathematics, science, and engineering	157	4.15	.775
Use engineering equipment	157	3.62	.971
Design a system, component, or process	157	3.65	.999
Interpersonal Skills			
Be flexible	152	4.16	.784
Be open minded	152	4.26	.744
Offer support and ideas to others	152	4.21	.667
Negotiate to reach a decision	152	4.01	.842
Work together and listen to others' opinions	152	4.15	.836
Handle conflicts	152	3.83	.905
Persuade others	152	3.64	.960
Build and maintain working relationships	152	3.95	.951
Community and Citizenship Knowledge			
Be aware of political issues	152	3.43	1.131
Be aware of social issues	151	3.62	1.064
Be aware of economic and environmental issues	151	3.69	1.008
Leadership Skills			
Motivate and supervise others	151	3.76	1.018
Coordinate and plan tasks	150	4.11	.866
Build team cohesion	151	3.73	.959
Professional Effectiveness			
Understand roles and responsibilities	149	4.22	.752
Understand professional and ethical responsibility	148	4.26	.792
Understand and respect other professionals	149	4.35	.779
Information and Communication Literacy			
Research information	147	3.90	.809
Identify relevant information	147	4.17	.706
Express and receive ideas clearly	147	4.05	.690
Write concisely	147	3.88	.913
Critical Thinking			
Generate new ideas	146	4.04	.742
Think critically	146	3.88	.913

Think and act independently	145	4.27	.802
Self-Management Skills			
Organize things effectively	144	4.10	.883
Self-reflection	144	4.01	.865
Manage time and meet deadlines	144	3.84	1.035
Be punctual to classes or meetings	144	4.17	1.040

Below are figures highlighting the demographic breakdown of the student respondents. Figure 4.1 shows the frequency of credit hours earned by the students that puts them into each academic grade level (freshman, sophomore, junior, and senior). Figure 4.2 shows the students that indicated if they have had engineering experiences or not. Figure 4.3 gives the gender frequencies and Figure 4.4 provides the frequencies of the racial and ethnic background of the students. 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.

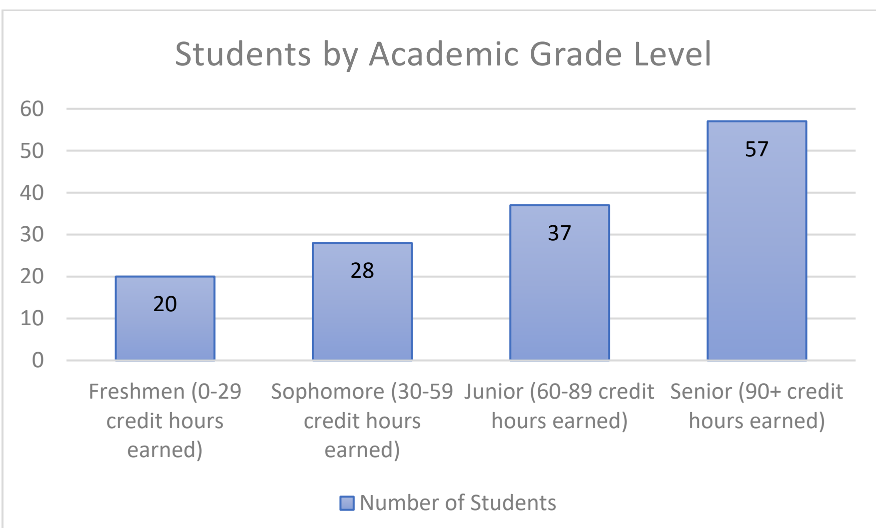

Figure 4.1. Distribution of Students by Academic Grade Level

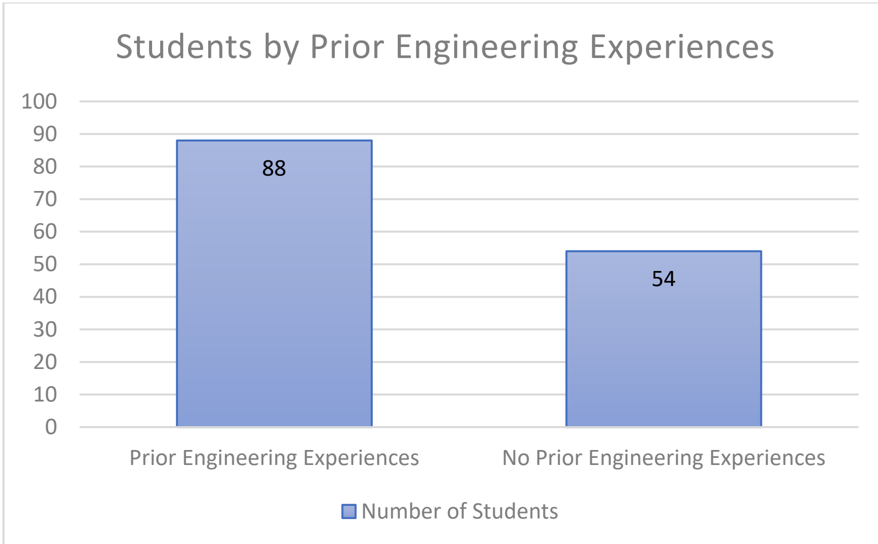

Figure 4.2. Distribution of students by Prior Engineering Experiences

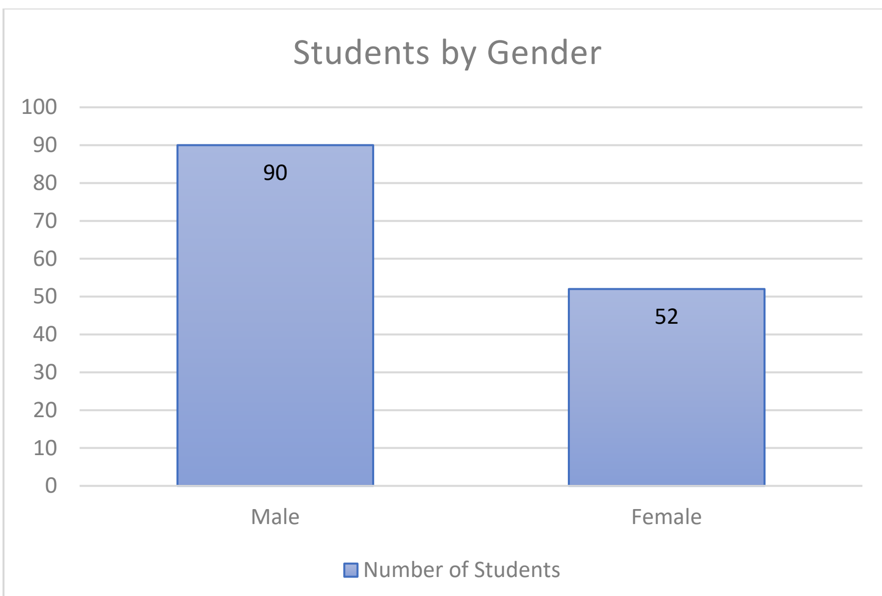

Figure 4.3. Distribution of Students by Gender

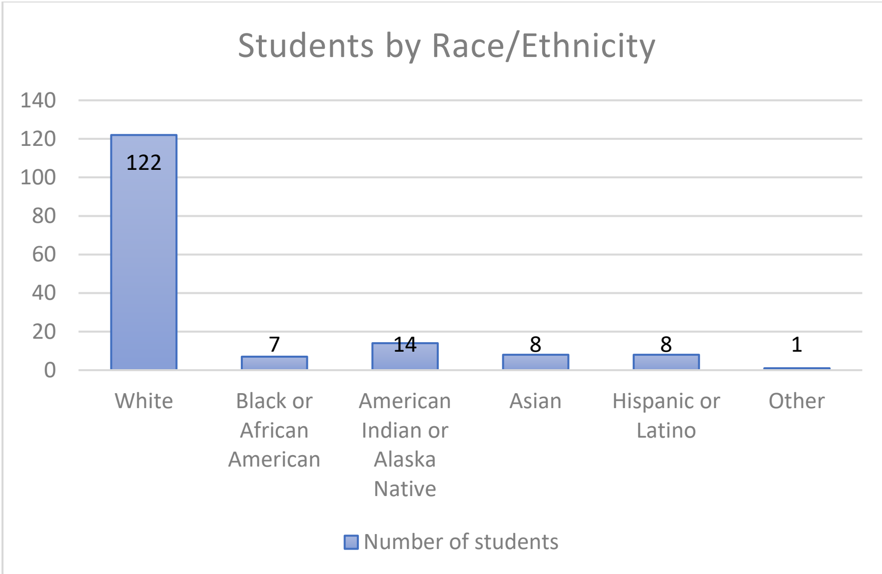

Figure 4.4. Distribution of Students by Race/Ethnicity.

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.

Confirmatory Factor Analysis

Confirmatory Factor Analysis was used to determine if the eight-factor model indicated by Chan, Zhao, and Luk (2017) held in this study. The model fit statistics were evaluated to determine the fit of the data. Table 4.2 provides the model fit statistics of both this study as well as those values reported by the instrument developers. Typically, the test statistics were held to the following thresholds: chi-square $p < .05$, CFI and TLI statistics $>.95$, the RMSEA $< .05$, and SRMSR $< .08$. The chi-square test statistic was heavily influenced by sample size.

Table 4.2

Confirmatory Factor Analysis Model Fit Statistics

Item	Current Study	Chan, Zhao, Luk (2017)
Chi-square Statistic	966.446	Not Reported
CFI	0.812	0.910
TLI	0.790	0.900
RMSEA	0.072	0.040
SRMSR	0.083	Not Reported

As shown in Table 4.2, the eight-factor model failed each model fit statistic test, whereas Chan et al., (2017) reported values that indicated the eight-factor model being a good fit. Reviewing the reliability of each of the individual scales utilizing Cronbach's Alpha, all values ranged from 0.634 to 0.838, which was consistent with the findings of Chan et al., (2017) where values ranged from 0.65 to 0.84.

Research Question One

The first research question explored differences in student perceptions of their generic skills competency level across academic grade level. This question was examined through the use of one-way ANOVA because there were four groups. Effect sizes were calculated using omega-squared (ω^2) for ANOVA tests and eta-squared (η^2) for Kruskal-Wallis tests. Prior to running the analysis, the data were reviewed based upon the assumptions of ANOVA. The data were not considered to be normally distributed but considered robust based upon having sample sizes larger than 12. All of the GSPQ items (dependent variables) – with the exception of Applying Knowledge of Math, Science, and Engineering, Being Aware of Political Issues, and Thinking Critically – met the assumption of homogeneity of variances.

For the three GSPQ items listed above, the Kruskal Wallis Test was applied. From the Kruskal Wallis Test, Being Aware of Political Issues and Thinking Critically were found to be significant ((χ^2 (3) = 10.921, p < 0.05, η^2 = .077), (χ^2 (3) = 9.549, p < 0.05, η^2 = .067), respectively). Applying Knowledge in Math, Science, and Engineering was not found to be significant. For the remaining items (32), one-way ANOVA results suggested that there was a significant difference in student perceptions of their generic skills for Designing System Components and Process (F(3, 138) = 3.579, p < 0.05, ω^2 = .052). Generating New Ideas was suggested to be significant at the p<0.10 level (F(3, 138) = 2.317, p < 0.10, ω^2 = .027). All other items were not found to be significant. Table 4.3 summarizes the items that were found to have significant differences.

Table 4.3

Research Question 1 Items of Significance

Survey Question	Analysis Method	Test Value	ω^2 or η^2
Being Aware of Political Issues	Kruskal Wallis	χ^2 (3) = 10.921*	.077
Thinking Critically	Kruskal Wallis	χ^2 (3) = 9.549*	.067
Designing System Component or Process	One-way ANOVA	F(3, 138) = 3.579*	.052
Generating New Ideas	One-way ANOVA	F(3, 138) = 2.317	.027

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

In a follow up post-hoc analysis of the significant items, pairwise comparisons of mean scores were reviewed to determine which academic grade levels were found to be different. Utilizing Games-Howell for those items without equal variances, the following pairwise comparisons were found to be significant. For Be Aware of Political Issues, significance was found between the Freshman and Sophomore groupings and again at the Sophomore and Senior groupings. For Thinking Critically, significance was found between the Sophomore and Senior Groupings. Utilizing Tukey for the items with equal variances, the following pairwise comparisons were found to be significant. For Designing System Components and Process, significance was found between the Sophomore and Senior groupings. In review of the Generating New Ideas, pairwise comparisons did not show significance between any of the groupings. Table 4.4 provides the means and standard deviations for each of the items by academic grade level.

Table 4.4

Research Question 1 Means (M), and Standard Deviations (SD) by Academic Grade Level for Significant Items

Survey Question	Freshman M (SD)	Sophomore M (SD)	Junior M (SD)	Senior M (SD)
Design System, Component or Process	3.45 (.686)	3.18 (1.090)	3.70 (.909)	3.88 (1.019)
Be Aware of Political Issues	3.75 (.639)	2.89 (1.197)	3.24 (1.164)	3.68 (1.121)
Generate New Ideas	4.20 (.768)	3.71 (.763)	4.11 (.774)	4.09 (.689)
Think Critically	4.35 (.813)	3.93 (.604)	4.14 (.713)	4.35 (.719)

The first hypothesis proposed that there would be differences for undergraduate students' generic skill competencies across academic grade level. This hypothesis was only supported by three items on the GSPQ at the $p < 0.05$ level, Being Aware of Political Issues, Thinking Critically, and Designing a System, Component, or Process, and one item (Generate New Ideas) at the $p<0.10$ level. The hypothesis was not supported by the data for all other items.

Research Question Two

The second research question explored differences of students with pre-graduation engineering experiences as compared to those without pre-gradation engineering experiences. This question was analyzed across the academic grade levels. As such, two-way ANOVAs were utilized to complete this analysis. Within the questionnaire, the students were given several options to select that were considered as pre-graduation engineering experiences:

1. Engineering Internship
2. Engineering Co-op
3. Engineering Service-Learning Activity (i.e. Engineers Without Boarders, etc.)
4. Engineering sponsored study abroad trip
5. Engineering competition team (i.e. Chem-E-Car, Speedfest, etc.)
6. Other External (outside of classwork) Engineering Activity (please list).

A variable called “pre-graduation engineering experiences” was created to indicate if the student did or did not participate in a pre-graduation engineering experience. If students selected any of the above options (with further review if item 6 was selected), they were coded as “yes” within the new variable using the numerical value of 1. If students did not select any of the options, they were coded within the collapsed variable as a 0 for “no”. 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.

The interaction of academic grade level and engineering experiences of the following items were found to be significant. For the items that had homogeneity of variance, Being Aware of Social Issues ($F(3, 133) = 2.330$, $p < 0.10$, $\omega^2 = .027$), was the only item found to have significance. The simple main effects were then reviewed for this item. For the item Being Aware of Social Issues, the simple main effect showed significance for Freshman with previous engineering experiences (M=4.30, SD=.949) reporting higher levels of competency than those Freshman without previous engineering experiences (M = 3.20, SD=.789) with a p-value of 0.02.

There were several items that while the interaction was not significant, the main effects were found to be significant. For the items that had homogeneity of variance, the main effect of Engineering Experiences was found to be significant for Design System Component Process ($F(1, 134) = 2.879$, $p < 0.10$, $\omega^2 = .012$), Being Flexible ($F(1, 134) = 3.280$, $p < 0.10$, $\omega^2 = .016$), Offer Support and Ideas to Others ($F(1, 134) = 5.477$, $p < 0.05$, $\omega^2 = .032$), Building and Maintaining Working Relationships ($F(1, 134) = 9.705$, $p < 0.01$, $\omega^2 = .059$), Motivate and Supervise Others ($F(1, 134) = 9.112$, $p < 0.01$, $\omega^2 = .055$), Coordinate and Plan Tasks ($F(1, 133) = 7.896$, $p < 0.01$, $\omega^2 = .047$), Build Team Cohesion ($F(1, 134) = 3.817$, $p < 0.10$, $\omega^2 = .020$), Understand Roles and Responsibilities ($F(1, 133) = 4.289$, $p < 0.05$, $\omega^2 = .023$), Generate New Ideas ($F(1, 134) = 6.796$, $p < 0.01$, $\omega^2 = .039$), Organize Things Effectively ($F(1, 134) = 6.258$, $p < 0.05$, $\omega^2 = .036$), and Self-Reflection ($F(1, 134) = 2.767$, $p < 0.10$, $\omega^2 = .013$).

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, Applying Knowledge of Math, Science, and Engineering ($F(1,140)=5.126$, $p<0.05$, $\omega^2 = .028$) 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: Designing and Conducting Experiments ($\chi^2 (1) = 11.856$, $p < 0.001$, $\eta^2 = .084$), Identify and Solve Engineering Problems ($\chi^2 (1) = 7.160$, $p<0.01$, $\eta^2 = .050$), and Be Aware of Economic and Environmental Issues ($\chi^2 (1) = 5.751$, $p<0.05$, $\eta^2 = .041$). Table 4.5 summarizes the means and standard deviations of the two groups (those with engineering experiences and those without engineering experiences) for those items with significance for the main effects.

For the item Be Aware of Economic and Environmental Issues, all of the items above showed significance at the main effects, indicating that those with engineering experiences reported higher levels of competency in this item compared to those without engineering experiences. All other items did not show significance for this main effect.

It should be noted that the item of 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 ($\chi^2 (3) = 10.921$, $p < 0.05$, $\eta^2 = .077$), which was reported above as a part of Research Question One.

Table 4.5

Research Question 2 Items of Significance Main Effects Test Value, Means (M), and Standard Deviations (SD) by Engineering Experience

Survey Question	Test Value	ω^2 or η^2	Prior Engineering Experiences M (SD)	No Prior Engineering Experiences M (SD)
Design and Conduct Experiments	χ^2 (1) = 11.856***	.084	3.93 (.640)	3.52 (.795)
Identify and Solve Engineering Problems	χ^2 (1) = 7.160**	.050	4.22 (.669)	3.80 (.939)
Apply Knowledge of Math, Science, and Engineering	(F(1,140) = 5.126	.028	4.25 (.715)	3.94 (.878)
Design System Component or Process	F(1, 134) = 2.879	.012	3.82 (.904)	3.33 (1.064)
Being Flexible	F(1, 134) = 3.280	.016	4.27 (.739)	3.98 (.858)
Offer Support and Ideas to Others	F(1, 134) = 5.477*	.032	4.31 (.613)	4.06 (.738)
Building and Maintaining Working Relationships	F(1, 134) = 9.705**	.059	4.15 (.810)	3.67 (1.046)
Be Aware of Economic and Environmental Issues	χ^2 (1) = 5.751*	.041	3.53 (1.050)	3.96 (.854)
Motivate and Supervise Others	F(1, 134) = 9.112**	.055	3.98 (.947)	3.52 (1.041)
Coordinate and Plan Tasks	F(1, 133) = 7.896**	.047	4.29 (.761)	3.93 (.949)
Build Team Cohesion	F(1, 134) = 3.817	.020	3.86 (.925)	3.59 (.981)
Understand Roles and Responsibilities	F(1, 133) = 4.289*	.023	4.33 (.638)	4.13 (.785)
Generate New Ideas	F(1, 134) = 6.796**	.039	4.18 (.687)	3.80 (.786)

Organize Things Effectively	F(1, 134) = 6.258*	.036	4.26 (.780)	3.85 (.979)
Self-Reflection	F(1, 134) = 2.767	.013	4.10 (.831)	3.85 (.920)

***indicates significance at the $p<0.001$ level, **indicates significance at the $p<0.01$ level, *indicates significance at the $p<0.05$ level, all others at $p<0.10$ level

The second hypothesis proposed that students with pre-graduation engineering experiences would score significantly higher on the GSPQ measures across academic grade level. This hypothesis only held true for the item of Being Aware of Social Issues; all other items were not significant at the interaction. However, upon review of the main effects, those with prior engineering experiences reported levels of competency significantly higher than those without prior engineering experiences for Design and Conduct Experiments, Identify and Solve Engineering Problems, Apply Knowledge of Math, Science and Engineering, Design System Component Process, Being Flexible, Offer Support and Ideas to Others, Building and Maintaining Working Relationships, Motivate and Supervise Others, Coordinate and Plan Tasks, Build Team Cohesion, Understand Roles and Responsibilities, Generate New Ideas, Organize Things Effectively, and Self-Reflection. Additionally, for the item Be Aware of Economic Issues, those without prior engineering experiences reported higher levels of competency compared to those with prior engineering experiences. All remaining items were not found to be significant at either the interaction or the main effects.

Research Question Three

The third 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. 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 females (M=4.58, SD=.507) reporting higher levels of competency than senior males (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 females (M=4.31, SD=.630) reporting higher levels of competency than sophomore males (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 males, with a p-value of 0.085. Tables 4.6 and 4.7 summarize the means and standard deviations for the simple main effects by significant item.

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 ($F(3, 134) = 2.449$, $p < 0.10$, $\omega^2 = .030$).

Table 4.6

Research Question 3 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 4.7

Research Question 3 Simple Main Effects Means (M), and Standard Deviations (SD) by Academic Grade Level for Males

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)

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 4.8 details the means and standard deviations for the significant items.

Table 4.8

Research Question 3 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

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, $p < 0.05$, $\eta^2 = .077$), which was reported above as a part of Research Question One.

Table 4.9

Research Question 3 Main Effects Test Value, Means (M), and Standard Deviations (SD) by Gender

Survey Question	Test Value	ω^2	Male M (SD)	Female 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

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, females reported higher levels of competency than males. Table 4.9 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.

The third 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.

Research Question Four

The fourth research question explored differences of students' race/ethnicity across the academic grade levels for the GSPQ items. In particular, it explored differences of students that identified themselves as White to those that did not select White as their race/ethnicity, or differences 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)

Due to the overwhelming majority selecting “White” (122), compared to those that selected one of the minorities (totaling 38 responses), the variable was collapsed into either selecting “White” (coded as 1) or not selecting “White” (coded as 0) to compare the majority race/ethnicity (i.e. White) 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). 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 4.10

Research Question 4 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	$\chi^2 (1) = 5.061$*	.033	3.35 (1.135)	4.00 (.816)
Be Aware of Social Issues	$\chi^2 (1) = 3.167$	.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 (χ^2 (1) = 5.061, $p < 0.05$, η^2 = .036), and Be Aware of Social Issues (χ^2 (1) = 3.167, $p < 0.10$, η^2 = .022). For each of these items, the Minority Race/Ethnicities reported higher levels of competency than the Majority Race/Ethnicity. Table 4.10 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, $p < 0.05$, η^2 = .077), which was reported above as a part of Research Question One.

The fourth 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.

Summary

This chapter detailed the statistical analysis utilized to examine the four research questions examined in this dissertation. A summary of the sample analysis and model fit of the questionnaire was provided. The findings were then detailed for each research question, as well as the hypotheses. The following chapter will present the conclusions drawn from this study, including implications for theory, research, and practice, as well as provide recommendations for future research.

CHAPTER V

CONCLUSIONS

The previous chapters in this dissertation provide important information related to the study's context, including a detailed literature review, methodology, and statistical analysis. This final chapter provides an overview of the study and the conclusions drawn from the analysis of the survey data gathered from undergraduate engineering students at a Midwestern research university. This chapter provides a review of the design, including the problem statement, purpose statement, methodology, and research questions. A summary of the data analysis is then provided for the four research questions. Implications of the study for theory, research, and practice are subsequently discussed, as well as recommendations for future research.

Statement of the Problem

Higher education engineering programs are consistently asked to provide quality assurance as a part of their program accreditation. This pressure comes from stakeholders such as hiring industries, parents of students, and the students themselves. ABET is the leading accreditor for undergraduate engineering programs in the United States and even internationally. ABET focuses its accreditation program on three main elements: student outcomes, self-assessment, and continuous improvement.

ABET student outcomes for engineering programs include seven criteria, none of which are discipline specific. These are sometimes referred to as professional skills, soft skills, or generic skills (Bennett et al., 1999). Self-assessment of these generic skills, such as problem solving, communication, teamwork, or critical thinking, can be difficult as many of them do not produce tangible results such as test scores. Faculty or hiring industry are those that typically assess these skills of the undergraduate engineering students. However, outcomes based assessment is most successful when all of the stakeholders are involved in the process (Duff, 2004). Students as a key stakeholder and their involvement in self-assessment can provide valuable information leading to continuous improvement of the individual engineering programs.

Because students are expected to gain competency in these generic skills or student outcomes, it is important to gain an understanding of their perceptions of their competencies in each of these skills. By obtaining the students' perception of their levels of competency of all the desired student outcomes, or generic skills, valuable insight can be gathered into students' skill development throughout undergraduate engineering programs. This will allow for a better understanding of what is needed for the continuous improvement process. The following paragraphs provide an overview of the research design utilized in this study.

Statement of the Purpose

The purpose of this study was to examine undergraduate engineering students' perceptions of their generic skills competencies across academic level, pre-graduation engineering experiences, and individual demographics at a research university located in the Midwest. The engineering programs associated with this study are those 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.

Review of Methodology

This research study was approached from an objectivist epistemology and subsequently a post-positivist theoretical perspective (Crotty, 1998). The study utilized survey research design, which allowed for a quantitative approach in data analysis as well as exploration of the relationships between the variables identified in the research questions.

The study sample was drawn from undergraduate students at a Midwestern research university. Utilizing purposeful sampling, the undergraduate students must have been a declared engineering major. This allowed for a large sample population.

The students were asked to participate in a survey where they self-assessed their competencies in generic skills. The student outcomes required by ABET accredited engineering programs tie closely to the generic skills the students were asked to self-assess. The survey was based on the Generic Skills Perception Questionnaire (GSPQ) developed by Chan et al (2017). The GSPQ data and demographic information from respondents allowed for exploration of the relationships between the variables.

The data were collected utilizing Qualtrics, an online survey platform. The data were analyzed using the computer program IBM Statistical Package for Social Sciences (SPSS) Version 23. The utilized quantitative methods included descriptive statistics and analysis of variance (ANOVA). Utilizing ANOVA allowed for examination of the relationships between student perceptions of their generic skills competency between academic grade level, pre-graduation engineering experiences, gender, and race/ethnicity.

Summary of Findings

Below is a summary of the findings for each of the research questions. A more detailed analysis is provided in the previous chapter. To aid the in following discussion, Figure 5.1 is provided summarizing the eight factors and corresponding items within the GSPQ. Within each research question, conclusions are drawn based upon current research within student learning outcomes.

Research Question One

The first research question was, are there mean differences across academic grade level when the GSPQ is administered to undergraduate engineering students at a Midwest research university? This question explored students' perceptions of their competencies in the skills presented in the GSPQ. One-way ANOVA was used to compare the group means. Students were grouped based upon their self-reported academic grade level. The boundaries for the academic grade levels were freshmen (0-29 credit hours earned), sophomore (30-59 credit hours earned), junior (60-89 credit hours earned), or senior (90+ credit hours earned).

Results of this analysis indicated that there were differences among students based upon academic grade levels. The significant findings included the items Designing a System, Component, or Process, Being Aware of Political Issues, Thinking Critically, and Generate New Ideas. For each of these the group means, the pattern to where the differences were found was among sophomores. Sophomores for these four items consistently perceived themselves less competent in these skills.

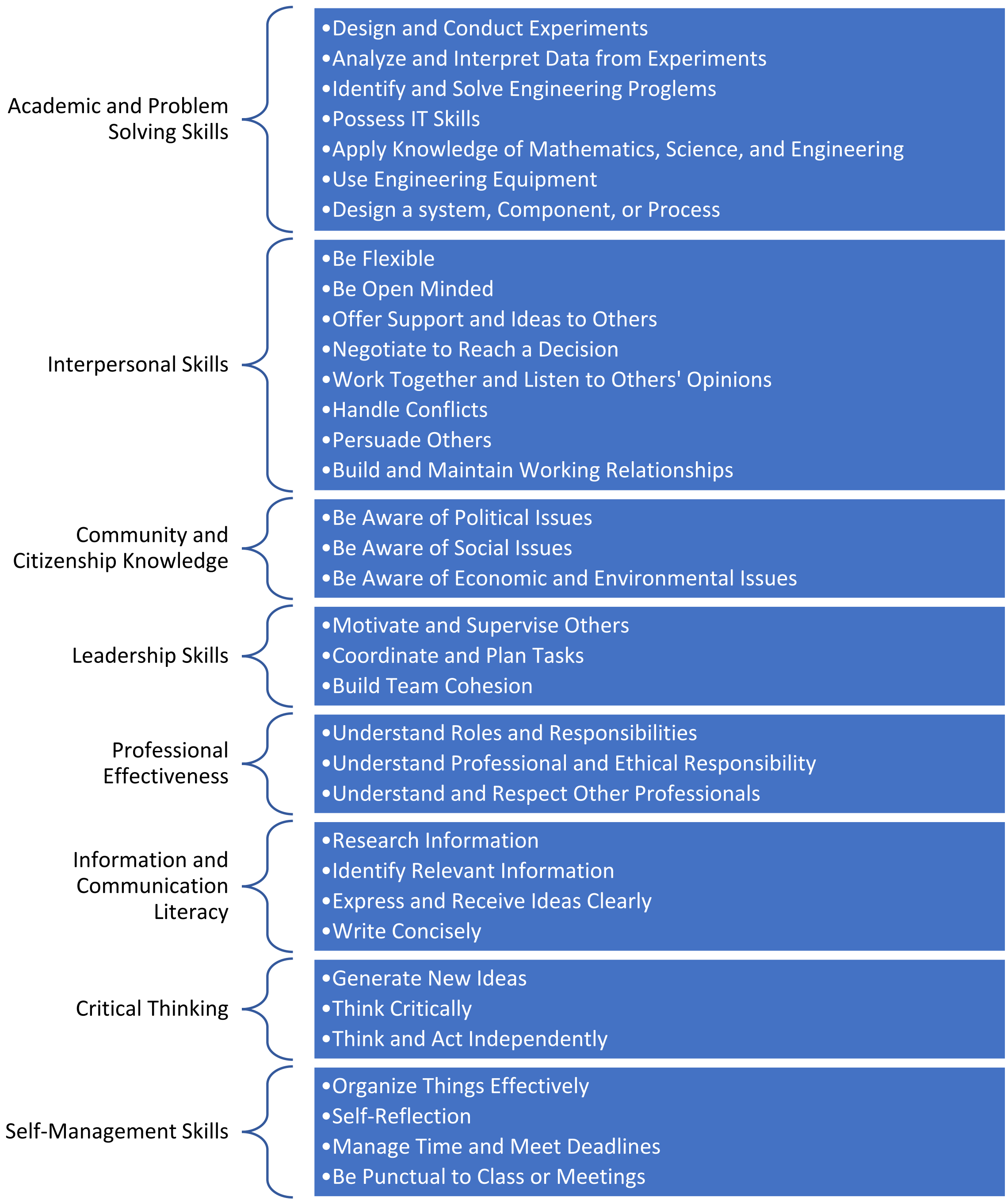

Figure 5.1. Generic Skills Perception Questionnaire Factors and Items (Chan et al., 2017)

This finding may be interesting in understanding a students' self-perception of their capabilities, which leads to a discussion in the students' self-perception of their overall development. This brief lack of confidence in their competency could be described as a deflection by Perry (1999). A deflection can fall into three categories, temporizing, escape, and retreat, all of which signal a person to cease to progress (if not regress) to the next position (Perry, 1999).

In reviewing the other items that were not deemed significant, one could still see differences among the four academic grade levels. For many of the items, the pattern was similar to that described above in that freshmen were confident in their competency, there was a dip in sophomores' competency, and increases in competency for juniors and seniors.

A final point to discuss, is that overall, students did perceive themselves above average in their competency of the skills presented in the GSPQ. There was not one skill that the overall mean was less than 3.40, as shown in Table 4.1. It is not until dividing the students into the academic grade levels did it reveal that there was a subset of students (sophomores) that may not perceive themselves as competent in skills.

Research Question Two

The second research question was, are there mean differences across academic grade level for undergraduate engineering students who had pre-graduation engineering experiences, as compared to undergraduate engineering students who did not have pre-graduation engineering experiences, when the GSPQ is administered to undergraduate engineering students at a Midwest research university? This question was analyzed utilizing 2-way ANOVA to compare the mean differences for those students with pre-graduation engineering experiences to those without pre-graduation engineering experiences across the academic grade levels. For this particular question there were a variety of findings.

The interaction of academic grade level and engineering experiences was significant for only one item, Being Aware of Social Issues. Looking at the simple main effects, the findings indicated that freshmen with prior engineering experiences reported higher levels of competency than those without prior engineering experiences. This means that the differences of this item diminish as students either gain the engineering experiences or progress in their academics, as the differences are no longer significant past the freshmen year. Interestingly, freshmen that have prior engineering experiences may also be more driven in that they sought out these experiences either prior to entering higher education or during their freshmen year.

Although none of the other items were considered significant at the interaction, several items were significant at the main effects level. For many of these items, students with prior engineering experiences reported levels of competency significantly higher than those without prior engineering experiences. These items were Design and Conduct Experiments, Identify and Solve Engineering Problems, Apply Knowledge of Math, Science and Engineering, Design System Component Process, Being Flexible, Offer Support and Ideas to Others, Building and Maintaining Working Relationships, Motivate and Supervise Others, Coordinate and Plan Tasks, Build Team Cohesion, Understand Roles and Responsibilities, Generate New Ideas, Organize Things Effectively, and Self-Reflection.

These fourteen items vary from technical generic skills to softer generic skills. The fourteen items covered six of the eight factors identified by Chan et al (2017). The first four items were part of the factor Academic and Problem-Solving Skills. It is easily understood how an engineering experience can boost students' perceived competency in these skills. Within each item, this infers application and experience. The engineering experiences may be the first time out of the classroom where students apply what they learned to Design and Conduct Experiments, Identify and Solve Engineering Problems, Apply Knowledge of Math, Science, and Engineering, or Design a System Component or Process.

The next three (Being Flexible, Offering Support and Ideas to Others, Build and Maintain Working Relationships) are all part of the factor of Interpersonal Skills. In different engineering experiences, students either need to utilize these skills or they see others utilizing them. For example, co-workers on an internship may offer support or ideas, or they may attend different team building activities, or they begin to understand that there may be times that one has to adjust to changing environments or problems by being flexible.

Motivate and Supervise Others, Coordinate and Plan Tasks, and Build Team Cohesion are all part of Leadership Skills. This was the one factor where all of the items were considered to be significant. This finding is important in that it shows that having prior engineering experiences may also prepare students to be future leaders in their chosen field.

Understand Roles and Responsibilities fell under the factor of Professional Effectiveness. Again, students with engineering experiences can probably easily identify their role in a given project and what that may have meant from a responsibility perspective. They were probably better able to relate to this item after having experienced it.

Within the factor of Critical Thinking, the item Generate New Ideas was significant for those with engineering experiences. This could be due to the concept that interns, co-ops, and engineering service-learning activities are given problems to solve at the start of an experience or if participating in a competition team, they have to come up with a new or improved way to do something to better their chances of succeeding.

The final factor with items of significance was Self-Management Skills. Students with engineering experiences perceived themselves as more competent in Organizing Things Effectively and Self-Reflection as compared to those students without engineering experiences. As many would agree, to get tasks done, students must be organized, so having experience in completing different tasks or projects would aid in this skill competency. Furthermore, it is common for students to look back on how well they completed something and what they could do to improve upon it. This could be done in project debriefings, after service-learning activities, or even after a competition. The job of an engineer is never done in that there are always things upon which to improve. An example of this was discussed earlier in Chapter Two for continuous improvement models and processes such as Six Sigma.

The finding of engineering experiences aiding in these generic skill competencies is consistent with prior research. For example, Harrisberger and Others (1976), through the American Society of Engineering Educators, indicated that learning through experience should be a key component of engineering education. Furthermore, Kolb's Learning Theory described that knowledge can be created through experience (1984).

Uniquely, for the item Be Aware of Economic and Environmental Issues, students without prior engineering experiences reported higher levels of competency compared to those with prior engineering experiences. One potential explanation is that those students, after having an engineering experience, did not feel as confident in this particular skill (i.e. the engineering experience either did not aid in the development or caused them to question their competency). Another reason could be that those without prior engineering experiences had other life experiences (outside of those of engineering) that made them more confident in their competency.

Looking at the items from a factor or category perspective, there are two in which engineering experiences demonstrated no significant differences, particularly where it was beneficial to competency. Community and Citizenship Knowledge, which includes Be Aware of Political Issues, Be Aware of Social Issues, and Be Aware of Economic and Environmental Issues, did not show that having prior engineering experiences aided in the self-competency of the student's ability. In fact, as detailed above, it appears that having prior engineering experiences gave the opposite effect on students' perceptions of being aware of economic and environmental issues. Looking at the grand means of all three of these items, they all fall between 3.43 and 3.69 on the Likert scale, which were the lowest in grand means for competency, with the exception of one item outside of this factor. This alludes to the idea that both higher education and engineering experiences are not effectively contributing to students' competency in this skillset.

The other factor that showed no significant differences was Information and Communication Literacy, which included items Research Information, Identify Relevant Information, Express and Receive Ideas Clearly, and Write Concisely. These items may potentially be properly addressed in academics and only reinforced in those individuals that have had engineering experiences resulting in no differences. Looking at the grand means of these four items, all items were at 3.88 or above on the Likert Scale, indicating students had confidence in their competency of these items.

Research Question Three

The third 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 females reported higher levels of competency than their counterpart males for Being Flexible. Additionally, sophomore females also reported higher levels of competency than sophomore males for Self-Reflection. Also, there was significance in the reported competency within among males' academic grade level for Self-Reflection. Similar to Research Question One, there was a dip in competency among males at the sophomore level, which may explain the significant difference among females and males at the sophomore level.

Reviewing the main effects, three of the same items in Research Question One were significant across academic grade level, Design System, Component, or Process, Be

Aware of Political Issues, and Think Critically. As discussed earlier, 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 females reported higher levels of competency than males.

Interestingly, for either the simple main effects or the main effects for gender, females showed a higher level of competency. Given the male dominated environment of engineering disciplines, this provides insight as to where females 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 females consistently self-assess themselves higher than males in professional or generic skills, but in contrast to Ro and Knight (2016) that females reported lower levels of design or technical skills.

Research Question Four

The fourth 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 collapsed into the category of 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 (2015) 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 (Ro & Loya, 2015). 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.

Summary

The preceding section drew conclusions based upon the data of the sample of undergraduate engineering students at a Midwestern research university and findings from existing research. The following section will detail implications of the findings and draw conclusions.

Implications

The outcomes of this study may have significance for student learning and development in the areas of research, theory, and practice. This study hopefully filled a gap in the research of students' generic skills competencies at the undergraduate level, while adding to the understanding of student development theory and contributing to the continuous improvement process of engineering academics.

Implications for Research

This research study contributed insight to the body of knowledge on undergraduate engineering student's self-assessment of their overall generic skill set. The study had students at a U.S. Midwest research university self-assess their competencies of their generic skills, most of which are considered required student learning outcomes by accrediting organizations, like ABET. The study gave a glimpse of where the students see themselves as being competent, especially when exploring differences among groups like academic grade level, engineering experiences, and demographics.

Academic grade level.

This dissertation gave insight as to when students in their academic career see themselves as competent and, maybe more importantly, when they do not see themselves as competent in the various skills. All of the items indicated that students, on average, deemed themselves as competent. However, that was as an entire student group which consisted of students at different times in their academic careers. Although there were only four items deemed significant based upon the statistical analysis, many of the skills followed a similar pattern of self-assessment of competency dipping at the end of the sophomore year.

This pattern is very telling in that freshmen may be overly confident in their competencies, but a correction is made during the sophomore year. This pattern is similar to what has become known as the Dunning-Kruger Effect, in that people tend to overestimate their competency in a given area the less they happen to know about that area (Kruger & Dunning, 1999). In other words, students do not know what they do not know. However, as students continue to progress in their academic career and take additional classes, their ability to self-assess their competencies may more accurately reflect their actual competency instead of the possible freshmen overestimation.

Considering the sophomore competencies as lower than the other academic years, discussion must include the curriculum experienced during the sophomore year. This survey was conducted at the end of the academic year (late Spring semester). This means that students who designated themselves as a sophomore were in the process of finishing their third or fourth semester. Looking at the curriculum for engineering schools, there are commonalities during the first two years. During the first and second years of engineering programs, students are typically expected to take multiple sciences and mathematics courses. These courses include chemistry or physics, mathematics classes such as Calculus 1, 2 or 3, and engineering science courses such as statics, strength of materials, thermodynamics, or fluid mechanics. All of these courses (or the varying combinations of them) provide the basic knowledge needed to move into specific disciplines. Additionally, many of them are pre-requisites to future classes. Sophomores' lower self-assessment of their competencies may reflect something greater, including student cognitive development or student burn-out, which could lead to retention issues at the sophomore level.

Research should continue to look at students based upon their development or progress within academia. This adds value to the body of knowledge as it tells a bigger picture of what occurs during students' progression in their academic programs and the impact it makes on their self-assessed competencies. This study provided validation for this work, particularly when exploring competencies of the subset of engineering students in higher education.

Pre-graduation engineering experiences.

This dissertation reaffirmed the need for practical experiences for engineering students in higher education. Although the interaction between Academic Grade Level and Pre-graduation Engineering Experiences was minimal, there were a large number of items that were significant based on the student having prior external engineering experiences. While there is much literature on how experiences can aid in the learning environment (which will be discussed further below), the findings in this study suggest that students with experiences tend to self-assess themselves as more competent in a variety of skills. Interestingly, this may lead to a more confident graduate willing to take on new roles and challenges for an employer because they perceive themselves as more competent then their counterparts that did not have pre-graduation engineering experiences. Students with these experiences may be more apt to 'hit the ground running' when they start full time employment after graduation, which is what more employers want from graduates. This study provided insight in that students with pre-gradation engineering experiences saw themselves as more competent in these skills. This may encourage more students to seek these experiences to make gains in their competency in these skills.

Gender.

There continues to be a big push to increase the number of women in STEM fields, which includes engineering. This dissertation revealed that women perceive themselves as more competent than their male counterparts 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 females can contribute to the engineering profession. The skills in which females indicated higher levels of competency are those skills that are often sought by employers.

Race/ethnicity.

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.

In conclusion, prior to this study the GSPQ instrument was utilized in Hong Kong by incoming freshmen. This study contributed a viewpoint of a cross section of students based upon academic grade level. Additionally, this study looked at differences among groupings of students beyond academic grade level, including the impacts of external engineering experiences and demographics.

Implications for Theory

This dissertation produced findings related to student development and learning theory, including Chickering and Reisser's Seven Vectors of Student Development, Kolb's Learning Theory, and Perry's Model of Intellectual and Ethical Development. Implications of each of these theories are subsequently discussed.

Chickering and Reisser's seven vectors of student development.

Chickering and Reisser's (1993) theory on student development includes seven vectors in which students move fluidly as they develop during their college years. This dissertation looked at students' development across the academic grade levels. Similar to the theory's flexibility regarding when students attain these different vectors – such as developing competence or moving through autonomy – the findings of this study support fluidity between the vectors. As discussed earlier, only four items were considered significant for differences between academic grade levels. This may be because at all four academic grade levels, students are continuously moving between their development in the vectors. There is not necessarily one point in a students' academic career that they have to attain these vectors. Therefore, this study could not necessarily show one academic grade level where significant strides are made in the vectors. However, many of the items in the GSPQ did show increases in students' perceptions of their competencies between the different academic grade levels, but not at the statistically significant level.

Of the four items that were significant, two (Critical Thinking and Generate New Ideas) are related to Chickering and Reisser's (1993) vector of Moving through Autonomy. This vector needs a student to break free from the need for reassurance and independently critically think to problem solve. The item Design a System, Component, or Process relates to Chickering and Reisser's first vector of Developing Competence, in particular, the area of intellectual competence where there is development of the mind to understand, scrutinize, and produce. The last item of significance Be Aware of Political Issues relates most closely to the vector of Developing Mature Interpersonal Relationships. Here, students begin to tolerate differences and increase awareness of various cultures or backgrounds (Chickering, 1993). This study supported that students' self-assessed competency was significantly different, in the positive direction, from sophomore to senior year.

On the other hand, this study showed that it takes two years to make statistically significant gains in these four skills (end of their sophomore year and the end of their senior year). This is telling, in that the significant gains hoped for in the other items in the GSPQ may not be significant until sometime after the student leaves higher education. This indicates that higher education likely provides the necessary framework for student development, but students continue to develop well beyond their graduation. This suggests that student development theories may apply to students well beyond their undergraduate years.

Perry's model of intellectual development.

This study supported Perry's Model of Intellectual Development, in particular it suggested that students at the end of their sophomore year may be in a period of deflection as defined by Perry (1999). Students within their sophomore year (within most items) consistently perceived themselves as less competent than the other academic grade levels, including freshmen. This finding is consistent with the retreat or temporizing type of deflections because it indicates that students may regress in that their growth or there is a pause in the growth in the different generic skill competencies. Within Perry's extensive studies and interviews during the development of the theory, it was often sophomores that indicated these periods of deflection (1999). This warrants further investigation on student attitudes at the midway point of their academic programs (i.e. end of sophomore year).

The significant findings of items Be Aware of Political Issues, Generate New Ideas, and Think Critically, relate to Perry's Model within the three positions of The Realizing of Relativism. This indicates that students are beginning to see that knowledge can be situational and relative. However, as indicated above, the lack of significant differences among the academic grade levels for the other items implies something about student development; it appears that changes are much smaller and incremental between the grade levels, providing validation for the need to assist the development of students at all academic grade levels to aid in their gains across Perry's main line of development and the nine positions (1999).

Kolb's learning theory.

This research study also provided a clear link to Kolb's Learning Theory. Fourteen different items showed significant difference in students' perception of their generic skills based upon prior engineering experiences. Kolb's (1984) theory is built on the idea that each experience leads to a higher level of reflective observation, abstract conceptualization, and active experimentation. This is similar to a coil, with each experience building on the others. This coil-like learning cycle leads to students reporting higher levels of competency because they had more engineering experiences.

This further validates the need to incorporate experiential learning in higher education, particularly undergraduate engineering programs.

Implications for Practice

Overall, the students see themselves as competent in these skills, but there are differences in some groupings. Additionally, there are skills that saw no significant differences. Although students perceive themselves as competent in the skills, there is evidence that employers do not believe graduates attained the skills to the level needed (*Bridge that gap*, 2013; Ejiwale, 2014). This dissertation produced information, as subsequently described, regarding areas where student development could be improved within engineering education. Two practical ways to support student development and learning are engineering program assessment strategies and pedagogy.

Assessment.

Assessment of learning outcomes is a key component of the accreditation process. However, based upon employer feedback that graduates of engineering programs do not have the generic skills desired, the assessment methodologies should be scrutinized to provide a complete picture of students' progress and development within engineering programs. During the ABET process, this student feedback may be able to demonstrate how students are (or are not) progressing on the skills. However, student feedback in the assessment process needs to be deeper than what is typically practiced. Students should not only provide feedback on if they liked or disliked certain classes or the methodologies for which they were graded, but also provide evidence of their perceptions of their learning outcomes. Using their perceptions, in conjunction with faculty and employer feedback, will provide a broader picture of how well a program is achieving student outcomes.

As shown in the findings of this study, student perceptions on all of the items required by ABET Student Learning Outcomes indicate which areas need improvement. Continuous improvement is one of the other pillars on which accreditation is built. Using information from students on the areas in which they need to improve would help programs to focus on those items for their continuous improvement process. For example, if it is known that students are making significant strides in an area such as Design System, Component or Process, a program could turn its focus to other items for improvement,

Pedagogy.

Looking at continuous improvement in the accreditation process, it is clear that one area in which engineering education can continue to improve is pedagogy. The study reiterated the need for experiential learning pedagogies in the classrooms. Engineering education should not be completely dependent upon external experiences to ensure that they attain different learning outcomes. Pedagogies that include active learning, project based learning, or hands-on laboratories can further aid in student's development of these skills.

Additionally, this study reveals differences in how students perceive themselves among demographics. Faculty should take this into account when working with students from racial, ethnic, or gender minorities. For example, female students may be more confident in the softer generic skills but will need more encouragement and validation in the technical generic skills to aid in their progression.

Curriculum and retention.

In addition to adjusting pedagogy to be more focused on experiential learning activities, continuous improvement must also reflect on the curriculum required of students. This relates to the course requirements during the sophomore year, students' cognitive development, and the risk of burn-out after the sophomore year. Programs may consider reviewing the retention of students after the sophomore year and how that may relate to the required courses and sequencing of those courses.

In conclusion, this study provides insight into students' perception of their achievement of these outcomes. This understanding of students' perceptions of their levels of competency offers information to undergraduate engineering programs seeking to develop these generic skills and retain students to graduation, which will likely increase the satisfaction of employers. Furthermore, understanding differences among engineering students' development of generic skills based upon demographics or pre-graduation engineering experiences may facilitate better development of curriculum and pedagogy to grow generic skills.

Limitations

Discussing the limitations of this dissertation is important. First, this study is based upon self-reported data from a survey. Respondents volunteered to opt-in to the survey. Because this particular questionnaire asked for students' self-perceptions of their skill set, students may have unintentionally (or intentionally) inflated or deflated their perceived competency level. The study assumed that participants truthfully responded regarding their abilities.

In addition, although the sample size was over 2,000 students, there was a low response rate of 158 responses used in the data analysis. Within the low response rate was a lower number of responses from minority race/ethnicities. This low response rate may not fully reflect the perceptions of minority race/ethnicities.

This study is only a single point in time and does not track students' perceptions throughout college (i.e. longitudinally). Additionally, this study did not consider students' cognitive learning levels or abilities or their current level of self-authorship. This study also did not address the faculty teaching techniques or mentoring that may have impacted students' perception of their competencies. Each of these is a limitation.

Finally, this study only accounted for the external engineering experiences previously listed. This study did not include other co-curricular or extracurricular activities in which students may have been involved. Each of the preceding limitations could be considered as a confounding variable.

Recommendations

This section makes recommendations based upon the findings and conclusions previously drawn. These recommendations are made hopefully to spur future research in the area of student learning outcomes in undergraduate engineering programs. Five potential avenues for future research are subsequently discussed.

GPSQ Instrument Analysis

The first recommendation is for further analysis of the GSPQ instrument. Because there were values in the model fit statistics for this study that fell below what is typically deemed as acceptable for Confirmatory Factor Analysis, there is a need for additional analysis of the GSPQ instrument. Although the model may not have had fit due to study's smaller sample size, or because this study was completed in a different cultural context, further exploration of the instrument seems important. Because it is a fairly new instrument and it was developed in Hong Kong, additional EFA and CFA should be completed. Additional studies should be completed that focus on potential expanded development and validation of the instrument.

Expansion of Current Study

A second recommendation is to expand this research to multiple universities with accredited engineering programs. This study only utilized a single Midwestern research university. However, ABET alone accredits over 4,000 programs through its four different accrediting commissions. These programs span 32 countries worldwide. Additionally, there may be other accrediting bodies that accredit engineering programs that could be a source for additional programs. Although not all of the 4,000 programs accredited by ABET are engineering programs (which is a separate recommendation discussed below), there are many different types of institutions of higher education that house engineering programs. There are regional and state public universities, private colleges, and historically black colleges and universities. All of these should be explored to better understand their students' perceptions of competencies. Students may choose a particular university for a variety of reasons; exploring different types of higher education institutions beyond the Midwestern research university used in this study will give additional students a voice. This additional research would facilitate greater generalizability.

An associated recommendation is to take this study beyond a single point in time. Conducting a longitudinal study of students as they progress through an academic program could provide valuable information on students' growth. Because students self-selected into the survey, many factors about the students were unknown and likely created limitations and confounding variables.

Exploration of Similar Disciplines

A third recommendation is to expand this research to disciplines that have similar student learning outcomes for accreditation. As indicated above, ABET has four different accrediting commissions that accredit over 4,000 programs worldwide. For example, engineering technology programs that are accredited through ABETs Engineering Technology Accreditation Commission (ETAC) are required to have similar student learning outcomes. Given that these programs are expected to assess students for similar generic skills, a study similar to this would be beneficial for those programs. Additionally, it would be beneficial to research other disciplines to see if students report similar competency levels or if there are differences in these students.

Exploration of Confounding Variables

Another recommendation is to look at the potential confounding variables discussed in the limitations. Two main approaches could be used to address the confounding variables. The first is to explore student perceptions in comparison to those of the faculty. The second is to examine more in-depth students' development, including cognitive development. For example, research could focus on pedagogy and the resulting student perceptions of their competencies. This study did not address how much active or experiential learning students had in the classroom setting. It did not assess the pedagogy used by a given faculty and/or if it matched well with the students' learning style. Understanding both the students' learning styles and the faculty teaching styles could strengthen an understanding of student competencies of generic skills. Additionally, exploration of students' critical thinking skills and the relationship with experiential learning should be researched more. This is an important avenue to explore because the findings show the impact of experiential learning on student self-perceptions.

Another confounding variable is the curriculum that students within engineering programs are expected to take during different times within a program. As shown in the data, sophomores found themselves less competent than counterparts. Future research should explore correlations between curriculum and self-perceptions of competencies.

Additionally, this study did not address students' cognitive ability. Doing so though could provide insight as to why freshman typically perceive themselves as more competent than respondents that were sophomores. Understanding students' cognitive ability could provide insight as to their responses for their perceived competency levels. Referring again to the Dunning-Kruger Effect, it could indicate if a student has an understanding of what they are responding to and if they truly can self-assess themselves accurately. Or, from another perspective, the students' level of self-authorship in conjunction with a study such as this could explain why students perceives themselves as competent (or not competent) in the different skills. Overall, expanding this study and isolating one or more of the confounding variables could strengthen findings and implications in student learning, accreditation, and continuous improvement.

Expanding Research on Perceptions of Competencies

A final recommendation is that student perceptions of their competencies should be researched more broadly. The need for graduates (whether in engineering or other disciplines) to have generic skills is not going away any time soon. Beyond just engineering or even ABET, there has been a push by many accreditors to be more outcomes based. Many regional accrediting bodies require universities to assess students' generic skill sets, such as communication and problem solving. So why not continue to research all students' perceptions of their competencies? Student perceptions facilitate the continuous improvement process by including all stakeholders and producing a more comprehensive understanding of undergraduate students.

Concluding Remarks

This dissertation explored the differences in student perceptions of their generic skills utilizing the GSPQ instrument. The study examined differences based upon academic grade level, prior engineering experiences, gender, and race/ethnicity. The findings indicated that undergraduate engineering students, in general, see themselves as having above average competency in these skills. Minimal significant differences were found for academic grade level. However, there were significant differences in the level of competency reported by students who had prior engineering experiences. Furthermore, there were differences in reported levels between gender and among the racial and ethnic minorities.

These findings indicate the need for undergraduate engineering programs and higher education institutions to engage in the continuous improvement process to provide the necessary resources to facilitate the development of these generic skills. The concept of student learning outcomes and accreditation, at both the institution and program level, is a key component in higher education. Understanding students' perceptions of their attainment of these outcomes (or skills) will hopefully allow for implementation of new pedagogies to promote growth in these skills. This growth, in turn, may enable employers to hire the graduates with the skills that are in high demand, resulting in a better built engineer.

REFERENCES

ABET. (2018a). Criteria for accrediting engineering programs, 2019-2020. Retrieved from https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/

ABET. (2018b). Self-Study Report Templates. Retrieved from http://www.abet.org/accreditation/self-study-templates/

Accreditation, C. f. H. E. (2010). Council for Higher Education Accreditation. *Recognition of Accrediting Organizations: Policy and Procedures.*

Aft, L. (2002). Evaluating higher education programs in quality. *Quality Progress, 35*(10), 30-31.

Astin, A. W. (2016). *Are you smart enough?* Sterling, VA: Stylus Publishing, LLC.

Baxter Magolda, M. B. (2008). Three Elements of Self-Authorship. *Journal of College Student Development, 49*(4), 269-284. doi:10.1353/csd.0.0016

Bennett, N., Dunne, E., & Carré, C. (1999). Patterns of core and generic skill provision in higher education. *Higher Education, 37*(1), 71-93. doi:10.1023/A:1003451727126

Bridge that gap. (2013). Retrieved from www.chegg.com

Chan, C. K. Y. (2012). Exploring an experiential learning project through Kolb's Learning Theory using a qualitative research method. *European Journal of Engineering Education, 37*(4), 405-415. doi:10.1080/03043797.2012.706596

Chan, C. K. Y., Zhao, Y., & Luk, L. Y. Y. (2017). A validated and reliable instrument investigating engineering students' perceptions of competency in generic skills. *Journal of Engineering Education, 106*(2), 299-325. doi:10.1002/jee.20165

Chesbrough, R. D. (2011). College Students and Service: A Mixed Methods Exploration of Motivations, Choices, and Learning Outcomes. *Journal of College Student Development, 52*(6), 687-705. doi:10.1353/csd.2011.0071

Chickering, A. W. (1993). *Education and identity* (2nd ed.. ed.). San Francisco, CA: Jossey-Bass Publisherss

Commission, H. L. (2019). HLC Policy. Retrieved from https://www.hlcommission.org

Creswell, J. W. (2014). *Research design : qualitative, quantitative, and mixed methods approaches* (4th ed.. ed.). Thousand Oaks, CA: Sage Publications.

Crotty, M. (1998). *The foundations of social research : meaning and perspective in the research process*. London ; Thousand Oaks, CA: Sage Publications.

Daniel, K. L., & Mishra, C. (2017). Student Outcomes From Participating in an International STEM Service-Learning Course. *SAGE Open, 7*(1), 2158244017697155. doi:10.1177/2158244017697155

Dewey, J. (1938). *Experience and Education*. New York, NY: The Macmillan Company.

Dillman, D. A. (2007). *Mail and internet surveys : the tailored design method* (2nd ed., 2007 update with new internet, visual, and mixed-mode guide.. ed.). Hoboken, NJ: Wiley.

Duff, J. M. (2004). Outcomes assessment across multiple accreditation agencies. *Journal of Industrial Technology, 20*(4), 1-7.

Eaton, J. S. (2012). An overview of U.S. accreditation. In. Washington D.C.: Council for Higher Education Accreditation.

Education, C. f. t. A. o. S. i. H. (2015). CAS learning and development outcomes. In *CAS professional standards for higher education* (9th ed.). Washington, DC.

Education, U. S. D. o. (2017). Accreditation in the United States, Subpart B - The Criteria for Recognition.

Ejiwale, J. A. (2014). Limiting skills gap effect on future college graduates. *Journal of Education and Learning, 8*(3), 209-216.

Ewell, P. T. (1998). National Trends in Assessing Student Learning. *Journal of Engineering Education, 87*(2), 107-113. doi:10.1002/j.2168-9830.1998.tb00330.x

Ezeldin, A. S. (2013). *International accreditation for engineering programs: Mission, learning objectives, and outcomes.* Paper presented at the 6th International Forum on Engineering Education.

Feisel, L. D., & Rosa, A. J. (2005). The Role of the Laboratory in Undergraduate Engineering Education. *Journal of Engineering Education, 94*(1), 121-130. doi:10.1002/j.2168-9830.2005.tb00833.x

Felder, R. M., & Brent, R. (2005). Understanding student differences. *Journal of Engineering Education, 94*(1), 57-72.

Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education, 78*(7), 674-681.

Feutz, M., & Zinser, R. (2012). Following engineering graduates. *The Journal of Technology Studies, 38*(1), 12-22.

Finster, D. (1989). Developmental Instruction: Part I. Perry's Model of Intellectual Development. *Journal of Chemical Education, 66*(8), 659. doi:10.1021/ed066p659

Gay, L. R., & Mills, G. E. (2016). *Educational research : competencies for analysis and applications* (9th ed.. ed.). Upper Saddle River, N.J.: Pearson.

Goodchild, L. F. (2002). History of higher education in the United States. In L. F. G. Harold S. Wechsler, Linda Eisenmann (Ed.), *The History of Higher Education* (3rd ed., pp. 36-52). Boston, MA: Pearson.

Harrisberger, L., & Others. (1976). *Experiential learning in engineering education*. Retrieved from Washington, D.C.: American Society of Engineering Educators

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Kruger, J., & Dunning, D. (1999). Unskilled and Unaware of It: How Difficulties in Recognizing One's Own Incompetence Lead to Inflated Self-Assessments. *Journal of Personality and Social Psychology, 77*(6), 1121-1134. doi:10.1037/0022-3514.77.6.1121

Lehre, A.-C., Hansen, A., Lehre, K. P., & Laake, P. (2014). Effects of the 2003 Quality Reform on Gender Gaps in Student Learning Outcomes in Norwegian Higher Education. *Scandinavian Journal of Educational Research, 58*(3), 315-336. doi:10.1080/00313831.2012.732602

LeMahieu, P. G., Nordstrum, L. E., & Cudney, E. A. (2017). Six Sigma in Education. *Quality Assurance in Education: An International Perspective, 25*(1), 91-108. doi:10.1108/QAE-12-2016-0082

Litchfield, K., Javernick-Will, A., & Maul, A. (2016). Technical and Professional Skills of Engineers Involved and Not Involved in Engineering Service. *Journal of Engineering Education, 105*(1), 70-92. doi:10.1002/jee.20109

Mann, C. R. (1918). A study of engineering education. *The Carnegie Foundation for the Advancement of Teaching*(Bulletin Number Eleven).

Marzagão, D. S. L., & Carvalho, M. M. (2016). Critical success factors for Six Sigma projects. *International Journal of Project Management, 34*(8), 1505-1518. doi:10.1016/j.ijproman.2016.08.005

McLeod, S. (2013). Kolb - Learning styles. *Simply Psychology.* Retrieved from https://www.simplypsychology.org/learning-kolb.html

Melguizo, T., & Wainer, J. (2016). Toward a Set of Measures of Student Learning Outcomes in Higher Education: Evidence from Brazil. *Higher Education: The International Journal of Higher Education Research, 72*(3), 381-401. doi:10.1007/s10734-015-9963-x

Merriam-Webster. (2017). Retrieved from https://www.merriam-webster.com/

Mills, G. E., & Gay, L. R. (2016). *Educational research : competencies for analysis and applications* (11th ed. ed.). Boston, MA: Pearson.

Mills, J. E., & Treagust, D. F. (2003). Engineering education - Is problem-based or project-based learning the answer? *Australasian Journal of Engineering Education*, 2-16.

National Academy of, E. (2004). *The engineer of 2020 : visions of engineering in the new century*. Washington, DC: Washington, DC : National Academies Press.

Neill, J. (Producer). (2005, January 26). John Dewey, the Modern Father of Experiential Education. *Wilderdom*. Retrieved from http://www.wilderdom.com/

Newfield, C. (2003). The rise of university management. In *The History of Higher Education* (pp. 346-358). Boston, MA: Pearson Custom Publishing.

Pavelich, M. J., & Moore, W. S. (1996). Measuring the effect of experiential education using the Perry Model. *Journal of Engineering Education, 85*(4), 287-292.

Perry, W. G. (1999). *Forms of intellectual and ethical development in the college years : a scheme* (1st ed.. ed.). San Francisco, CA: Jossey-Bass Publishers.

Prados, J. W., Peterson, G. D., & Lattuca, L. R. (2005). Quality assurance of engineering education through accreditation: The impact of Engineering Criteria 2000 and its global influence. *Journal of Engineering Education*(January), 165-184.

Quality, A. S. f. (2019). Continuous Improvement. Retrieved from https://asq.org/quality-resources/continuous-improvement

Reform, G. o. E. (2019). The Glossary of Education Reform. Retrieved from https://www.edglossary.org

Ro, H. K., & Knight, D. B. (2016). Gender Differences in Learning Outcomes from the College Experiences of Engineering Students. *Journal of Engineering Education, 105*(3), 478-507. doi:10.1002/jee.20125

Ro, H. K., & Loya, K. I. (2015). The Effect of Gender and Race Intersectionality on Student Learning Outcomes In Engineering. *The Review of Higher Education, 38*(3), 359-396. doi:10.1353/rhe.2015.0014

Ruutmann, T., & Kipper, H. (2013). Rethinking effective teaching and learning for the design of efficient curriculum for technical teachers. *International Journal of Engineering Pedagogy, 3*(1), 44-51.

Salkind, N. J. (2017). *Statistics for people who (think they) hate statistics* (Sixth edition.. ed.): Thousand Oaks : SAGE Publications, Inc.

Samman, R. A., & Ouenniche, J. (2016). Continuous quality improvement programs—part i: survey, critical analysis and future research directions. *The Journal of Developing Areas, 50*(4), 39-66. doi:10.1353/jda.2016.0152

Scholl, K., & Olsen, H. M. (2014). Measuring student learning outcomes using the SALG instrument. *Schole: A Journal of Leisure Studies and Recreation Education, 1*, 37-50.

Schray, V. (2006). *Assuring Quality in Higher Education: Key Issues and Questions for Changing Accreditation in the United States*. Retrieved from

Stage, F. K., & Manning, K. (2016). *Research in the college context : approaches and methods* (Second edition.. ed.): New York, NY : Routledge, Taylor & Francis Group.

Taghizadegan, S. (2013). *Mastering Lean Six Sigma : advanced black belt concepts*. New York, NY: Momentum Press.

Terenzini, P. T., Cabrera, A. F., Colbeck, C. L., Parente, J. M., & Bjorklund, S. A. (2001). Collaborative Learning vs. Lecture/Discussion: Students' Reported Learning Gains*. *Journal of Engineering Education, 90*(1), 123-130. doi:10.1002/j.2168-9830.2001.tb00579.x

Volkwein, J. F., Lattuca, L. R., Harper, B. J., & Domingo, R. J. (2007). Measuring the impact of professional accreditation on student experiences and learning outcomes. *Research in Higher Education, 48*(2), 251-282.

Zhao, L. (2011, 8-10 Aug. 2011). *China's higher education quality management based on Six-Sigma management principles.* Paper presented at the 2011 2nd International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC).

APPENDIXES

APPENDIX A

INSTRUMENT USE PERMISSION

From: Dr. Cecilia Chan
To: Charter, Virginia; Maggie Zhao; Lillian Luk
Subject: RE: Engineering Students" Generic Skills Instrument
Date: Wednesday, October 25, 2017 9:18:43 PM

Dear Virgina

Thank you for your email.
We are happy that you plan to adapt our Generic Skills Instrument, and of course, it is possible.

Best of luck in your PhD.

Kind regards
Cecilia

From: Charter, Virginia [mailto:virginia.charter@okstate.edu]
Sent: Wednesday, October 25, 2017 2:31 AM
To: Dr. Cecilia Chan <cecilia.chan@cetl.hku.hk>; Maggie Zhao <myzhao@hku.hk>; Lillian Luk <llyy@hku.hk>
Subject: Engineering Students' Generic Skills Instrument

Dr. Chan, Dr. Zhao, & Dr. Luk,

My name is Virginia Charter and I am a PhD student in the Oklahoma State University in the Educational Leadership and Policy Studies - Higher Education program. I am interested in possibly using your Engineering Students' Generic Skills Instrument that you published on in JEE in April of 2017. This would be for my dissertation. Is this a possibility?

Thank you in advance for your response.

Warm regards,

Virginia R. Charter, PE
Assistant Professor
Fire Protection and Safety Engineering Technology
Oklahoma State University

APPENDIX B

PARTICIPANT INVITATION

Initial Email Invitation

Good Afternoon! My name is Virginia Charter and I am a PhD student in Educational Leadership and Policy Studies – Higher Education at Oklahoma State University.

I am writing today to ask for your assistance in my dissertation research. Specifically, I am inviting you to participate in a brief survey about your perceptions of the generic skills you are gaining in your engineering program. The survey, which can be accessed by the link below, will take less than 15 minutes. The survey is related to your assessment of your current level of competency in each skill.

Participation in the survey is voluntary and all answers are completely anonymous.

Thank you in advance with your assistance with this study.

To participate in the study, please click here: <insert link>

Virginia Charter

Follow-up Email

Good Afternoon! My name is Virginia Charter and I am a PhD student in Educational Leadership and Policy Studies – Higher Education at Oklahoma State University.

I am writing you today to follow-up on my previous email asking for your assistance in my dissertation research. Specifically, I am inviting you to participate in a brief survey about your perceptions of the generic skills you are gaining in your engineering program. If you are already participated in the survey, Thank you! If you have yet to participate, the survey may be accessed at the link below and will take less than 15 minutes. The survey is related to your assessment of your current level of competency in each skill.

Participation in the survey is voluntary and all the answers are completely anonymous.

Thank you in advance with your assistance with this study!

To participate in the study, please click here: <insert link>

Virginia Charter

Final Email

Good Afternoon! My name is Virginia Charter and I am a PhD student in Educational Leadership and Policy Studies – Higher Education at Oklahoma State University.

I am writing you today to follow-up on my previous emails asking for your assistance in my dissertation research. Specifically, I am inviting you to participate in a brief survey about your perceptions of the generic skills you are gaining in your engineering program. If you are already participated in the survey, Thank you! If you have yet to participate, the survey may be accessed at the link below and will take less than 15 minutes. The survey is related to your assessment of your current level of competency in each skill.

Participation in the survey is voluntary and all the answers are completely anonymous.

Thank you in advance with your assistance with this study!

To participate in the study, please click here: <insert link>

Virginia Charter

APPENDIX C

GENERIC SKILLS PERCEPTION QUESTIONNAIRE

As you answer the following questions, please consider what you believe that your competency level is in the following **Academic and Problem-Solving Skills**:

Academic and Problem-Solving Skills	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
Design and conduct experiments	1	2	3	4	5
Analyze and interpret data from experiments	1	2	3	4	5
Identify and solve engineering problems	1	2	3	4	5
Possess IT Skills	1	2	3	4	5
Apply knowledge of mathematics, science, and engineering	1	2	3	4	5
Use engineering equipment	1	2	3	4	5
Design a system, component, or process	1	2	3	4	5

As you answer the following questions, please consider what you believe that your competency level is in the following **Interpersonal Skills**:

Interpersonal Skills	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
Be flexible	1	2	3	4	5
Be open minded	1	2	3	4	5
Offer support and ideas to others	1	2	3	4	5
Negotiate to reach a decision	1	2	3	4	5
Work together and listen to others' opinions	1	2	3	4	5
Handle conflicts	1	2	3	4	5
Persuade Others	1	2	3	4	5
Build and maintain working relationships	1	2	3	4	5

As you answer the following questions, please consider what you believe that your competency level is in the following **Community and Citizenship Knowledge Skills**:

Community and Citizen Knowledge Skills	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
Be aware of political issues	1	2	3	4	5
Be aware of social issues	1	2	3	4	5
Be aware of economic and environmental issues	1	2	3	4	5

As you answer the following questions, please consider what you believe that your competency level is in the following **Leadership Skills**:

Leadership Skills	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
Motivate and supervise others	1	2	3	4	5
Coordinate and plan tasks	1	2	3	4	5
Build team cohesion	1	2	3	4	5

As you answer the following questions, please consider what you believe that your competency level is in the following **Professional Effectiveness Skills**:

Professional Effectiveness Skills	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
Understand roles and responsibilities	1	2	3	4	5
Understand professional and ethical responsibility	1	2	3	4	5
Understand and respect other professionals	1	2	3	4	5

As you answer the following questions, please consider what you believe that your competency level is in the following **Information and Communication Literacy Skills**:

Information and Communication Literacy Skills	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
Research information	1	2	3	4	5
Identify relevant information	1	2	3	4	5
Express and receive ideas clearly	1	2	3	4	5
Write concisely	1	2	3	4	5

As you answer the following questions, please consider what you believe that your competency level is in the following **Critical Thinking Skills**:

Critical Thinking Skills	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
Generate new ideas	1	2	3	4	5
Think critically	1	2	3	4	5
Think and act independently	1	2	3	4	5

As you answer the following questions, please consider what you believe that your competency level is in the following **Self-Management Skills**:

Self-Management Skills	**Very Poor**	**Poor**	**Average**	**Good**	**Very Good**
Organize things effectively	1	2	3	4	5
Self-reflection	1	2	3	4	5
Manage time and meet deadlines	1	2	3	4	5
Be punctual to classes or meetings	1	2	3	4	5

Please answer the following demographic questions:
Gender:
Female
Male

Age:

Race/Ethnicity (select all that apply):
White
Hispanic or Latino
Black or African American
Native American or American Indian
Asian/Pacific Islander
Other (please list)

Country of Origin:

Declared Program of Studies (if double major, please select all that apply):
Aerospace Engineering
Architectural Engineering
Biosystems Engineering
Chemical Engineering
Civil Engineering
Computer Engineering
Electrical Engineering
Industrial Engineering and Management
Mechanical Engineering
Other (please list)

Number of Credit Hours Earned as of the END of Fall 2018 semester (do not include hours enrolled in this semester):
29 hours or less
30 – 59 hours
60 – 89 hours
90 hours or more

Have you ever participated in one of the following activities? (select all that apply)
Engineering Internship
Engineering Co-op
Engineering Service-Learning Activity (i.e Engineers Without Boarders, etc.)
Engineering sponsored study abroad trip
Engineering competition team (i.e. Chem-E-Car, Speedfest, etc.)
Other External (outside of classwork) Engineering Activity (please list):

VITA

VIRGINIA CHARTER

Candidate for the Degree of

Doctor of Philosophy

Dissertation: BUILDING A BETTER ENGINEER AND ROUNDING OUT ASSESSMENT: STUDENT PERCEPTIONS OF THEIR GENERIC SKILLS COMPETENCY

Major Field: Educational Leadership and Policy Studies – Higher Education

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Educational Leadership and Policy Studies – Higher Education at Oklahoma State University, Stillwater, Oklahoma in December, 2019.

Completed the requirements for the Master of Science in Fire Protection Engineering at Worcester Polytechnic Institute, Worcester, Massachusetts in May, 2012.

Completed the requirements for the Bachelor of Science in Engineering Technology in Fire Protection and Safety Engineering Technology at Oklahoma State University, Stillwater, Oklahoma in May, 2005.

Experience: Assistant Professor and Program Coordinator in Fire Protection and Safety Engineering Technology, Oklahoma State University; Senior Consultant, Rolf Jensen and Associates, Inc.; Associate Manager, Rolf Jensen and Associates, Inc.; Consultant, Rolf Jensen and Associates, Inc.; Associate, Rolf Jensen and Associates, Inc.

Professional Memberships: Society of Fire Protection Engineers (SFPE), National Fire Protection Association (NFPA), American Society of Engineering Educators (ASEE).