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An Exploratory Study of Global Competencies Considered by Multinational Companies: A Hiring Perspective*

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Research in global competency for engineers often focuses on what colleges and universities can provide to their students in terms of intercultural and global experiences. There is also an impetus to study how employers view global competency, and what can be done to align employer expectations with how global competency is valued and practiced within higher education institutions. This study explores the importance that 442 employers from more than 20 multinational companies place on engineering global competencies when making hiring decisions. Furthermore, we investigate how contextual factors of an employer such as gender, job title, and company size affect the views and attitudes of these engineering global competency traits in the workplace. It is imperative that engineering programs work closely with companies that have a global footprint in order to further identify and reduce the gap between global industry demands and what skills colleges are developing among their student populations.

Keywords: engineering global competency; industry perspective; contextual factors; correlation; multinational company; hiring decisions

1. Introduction

As companies continue to increase their global reach, it is vital for newly graduated engineering students to be prepared by developing global competencies prior to entering the workforce. The need for the identification and assessment of these competencies has been a focus of industry leaders as well as researchers. Today, many now recognize that engineering work involves interaction in transnational environments [1–4]. Engineering programs are responsible for producing globally competent graduates who, by working cross culturally and across national boundaries, can effectively identify opportunities, understand global market forces, and successfully commercialize new technologies [5]. An additional set of global attributes and skills must be developed, such as good communication skills, including multiple languages; the ability to work in teams; cross-cultural sensitivity and knowledge; social awareness; capacity to handle complex systems; business acumen and sense of entrepreneurship [6]. An understanding of globalization is key to an engineer's success in today's global society. It will be these fundamental capacities that will enable 21st-century engineers to develop into professionals capable of working successfully both domestically and globally, highly respected by the general public, and regarded the world over as professionals of the highest order [7]. For the purposes of this research, global competency is defined as "having an open mind while actively seeing to understand cultural norms and expectations of others, leveraging this gained knowledge to interact, communicate, and work effectively outside one's environment [8].

In this study, we built upon the prior work outlined above to examine the importance of these global competency skills from the perspective of industry. The goal of our work was to investigate how current engineering employers view the knowledge, skills, and attributes that impact an engineer's ability to be successful in a global work environment. This research addressed the following research goals:

(1) Explore how employers view global competency and how these competencies play a role in the hiring and success of engineering graduates.
(2) Explore how these views change as a function of employer characteristics such as gender, job title, and company size.

Our work was motivated by the interest of universities, specifically engineering programs, to prepare students to meet the expectations of the global

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workforce by offering and encouraging different international and intercultural opportunities. When considering the development of such programs, it is essential that they be strategically aligned with skills that are highly valued by employers as contributing towards global competency. To produce successful globally competent engineers (with the accompanying skill sets), the gap between employers' global competence expectations and how engineering programs integrate global competence into its curriculum must be better understood and reduced. Engineering programs and the general body of research would benefit from the exploration of how employers view global competency when making hiring decisions and what company profile characteristics affect these viewpoints.

2. Review of the literature

2.1 Study motivation

Business in the 21st century continues to become more globalized, leading to an increase in the frequency of interactions among people of different cultural and ethnic backgrounds. Today, products and services of multinational corporations are developed, designed, and produced by engineers who, while trained domestically, find themselves in key roles in a global economy. While the U.S. ranks as one of the most technologically advanced countries, there is a serious risk that the number of native born engineers and scientists produced will fail to sustain a competitive edge. According to Open Doors Data, over 141,000 international students study engineering in the U.S each year in 2011/12, accounting for almost 19% of the international students who study abroad in the U.S. In contrast, only 11,000 engineering students from the U.S. are going abroad, which only accounts for 3.9% of the total U.S study abroad population [9]. As a result, international students already have an engineering global competency advantage over their U.S student counterparts.

Multinational corporations are major stakeholders in the global competency of their newly hired graduates, indicating they prefer engineers with international mobility to provide diversity in engineering and R&D skills in locations throughout the world [10]. Global competency has become an important educational outcome and is a natural extension to recent concerns by a number of national commissions as well as scholars [8, 11, 12]. The report *Global Competence & National Needs: One Million Americans Study Abroad* prepared by the Commission on the Abraham Lincoln Study Abroad Fellowship Program in 2005 make some salient points which highlight the importance of a globally competent workforce, noted by [13], including:

(1) Fully one in six American jobs is now tied to international trade;
(2) Corporate leaders rank international curricula high on their priority list of what is important in higher education; and
(3) There is near unanimity among American personnel officers that job applicants with international experience are likely to possess desirable skills in cross-cultural communication, cultural awareness, leadership and independence.

Additionally, the *Final Report of the Global Engineering Excellence Initiative* study, which is an industry sponsored study on global engineering excellence regarding the education of the next generation of engineers who will take their place in a global work environment, outlined four critical challenges that face the preparation of tomorrows engineering workforce. These challenges, outlined in [14] include:

(1) Global competency needs to become a key qualification of engineering graduates;
(2) Transnational mobility for engineering students, researchers, and professionals needs to become a priority;
(3) Global engineering excellence is critically dependent on a mutual commitment to partnerships, especially those linked to professional practice; and
(4) There is an urgent need for research on engineering in a global context.

The cultural and economic effects of globalization have created a need for fundamental changes in engineering education, and have increased the importance of the industry and academic partnership.

2.2 Industry perspective of competencies

There have been numerous research studies that focus on an industry perspective of the relevant competencies of graduating engineers. Educators now face the difficult task of looking at how to contextualize learning to achieve more complex competencies within a rapidly changing global world [15]. However, research on student learning outcomes has showed that engineering graduates are not necessarily developing the skills required by industry [15–18]. The global mobility of the engineering profession, multicultural workplace environments, growth in student enrollment and graduating in engineering were highlighted as key issues that need to be addressed [17]. There is increasing evidence of mismatch between graduated student's skills developed during their studies and those needed in the workplace. Numerous scholars in a variety of disciplines have developed their own studies to address this mismatch, of which global competency was included.

Parkinson presented 13 dimensions of global competence and survey results from engineering educators and leaders in industry regarding the relative importance of these dimensions [19]. These dimensions ranged from the ability to appreciate other cultures to viewing themselves as "citizens of the world" as well as citizens of a particular country. After surveying educators and leaders in industry, the five most important global competency attributes were: (1) Can appreciate other cultures; (2) Are proficient working in or directing a team of ethnic and cultural diversity; (3) Are able to communicate across cultures; (4) Have had a chance to practice engineering in a global context; and (5) Can effectively deal with ethical issues arising from cultural or national differences. Furthermore, industry respondents from this study (representing 12 companies) indicated that the importance of global competence for engineering graduates to be between "highly desirable" to "essential" [19].

Ball et al. conducted research to outline a comprehensive set of engineering global competencies, along with a corresponding conceptual model, that was validated by engineering academics and industry experts [4]. By administering a survey to both of these populations (37 industry experts and 42 academic experts), it was found that the most important global competencies involve attitudes and abilities focused on working effectively with individuals in culturally diverse team settings. In contrast, acquiring a second language, representing your company or culture, and developing a desire to learn about world cultures were deemed relatively less important. Specifically, the top rated competencies according to the industry respondents were: appreciate and respect cultural differences, collaborate and work on a multicultural team, use collaboration technologies in intercultural interactions, practice tolerance and flexibility, and practice cultural equality [4].

Warnick has also conducted extensive research on global competence and its importance for engineers working in global environments. While his study focused on ABET specified engineering learning outcomes in the set of skills to assess along with eight categorized global competencies, the top global competencies valued by the surveyed employers were the ability to communicate cross-culturally, followed by the appreciation and understanding of different cultures and the ability to work in international teams [20].

2.3 Factors affecting viewpoints of competencies

According to Passow, the overall pattern of importance in competencies (in general) depends on the practice setting. That is, different academic disciplines and work environments require different competencies and different relative importance among them [21]. In his study, undergraduate engineering alumni were surveyed on how they value certain ABET competencies (in which global competency was included) in their professional experience. Passow found that groups of alumni differed in their responses based on work environment and academic major, and not necessarily on variables that are demographic in nature or time-related [21]. Passow's work supports the theory of vocational behavior which says that each environment, whether it is a work environment or an academic discipline, has a distinctive pattern of competencies, values, attitudes, interests, and self-perceptions [22].

Another theory called "models for superior performance" synthesized 286 studies of the characteristics of people who perform well at various jobs. Its two central findings were (1) that there is a different overall pattern of importance among the competencies for different jobs and (2) that generic models will not fit any specific job perfectly because there is such variation in the competencies required in different jobs [23]. A third theory, by Stark, Lowther, and Hagerty posits that patterns of importance among competencies are based on professional field [24]. Part of the dissertation work done by Warnick aimed at determining the influence different variables had on the relative importance of competencies when hiring mechanical engineers to work in a global environment [20]. He found that mechanical engineering alumni who worked for larger companies, in terms of annual revenue and number of employees, placed a higher importance on global competence than did those who worked for smaller companies. This study also found a positive correlation between job title and a high GPA, but a negative correlation between job title and the ability to speak more than one language including English.

In the study conducted by Ball et al, a cursory analysis was done on how contextual factors influence the importance ratings of various global competencies specifically. They found that Managers and Directors considered using collaboration technologies in intercultural interaction as very important, whereas all other job-types regarded this competency with relatively less importance [4]. Moreover, Ball et al aggregated their results based on respondent geographic location, job title, academic background, and former international experience. Interestingly, there were no significant differences in academic responses.

2.4 Novelty of research

Our study draws upon this prior research and extends to a more robust set of variables to build upon these findings. We expand upon these previous studies by increasing the sample size and diversity of respondents from industry settings. We addressed two areas currently in need of further exploration in the area of engineering global competency. First, we focused on the responses of those alumni *directly involved in hiring,* as opposed to analyzing the responses from all alumni, who may not have a major role or experience in the hiring process. This allowed us to determine if there is a match between the people who value global competencies and those who are actually doing the hiring. Second, unlike much of the work cited above, we are primarily interested in how *global competencies* specifically are affected by contextual factors such as industry segment, job title, and company size. This approach provides benchmark information for engineering departments and programs that they can use to evaluate their approach in preparing their students to successfully become globally prepared engineers.

3. Methodology

3.1 Research design and study context

The purpose of this study was to evaluate whether those directly involved in making hiring decisions at multinational companies consider global competence an important skill in engineering graduates. We were also interested in what kind of global competencies are considered the most important when making hiring decisions and how contextual factors such as industry segment, job title, and company size affect an employer's viewpoint on global competency.

From an academic perspective on the current state of engineering global competence, there is still limited consensus on how to define global competence, how best to develop global competence in engineering students, and how to match the learning outcomes from international experiences to appropriate assessment instruments [12]. From an employers' perspective, there is a lack of grounded research on how multinational companies view global competencies (knowledge, awareness, and skills) in respect to the traditional technical competencies, and how employers differ in this regard. To this end we developed an exploratory descriptive study using survey information from industry respondents to help facilitate a meaningful discussion on how employers view global competencies, and what higher education institutions can do to better prepare their students to enter the global workforce. Exploratory studies are constructed when there is scarce knowledge about a particular issue or topic and/or the research objective of such studies is uncertain. Given the nature of the study, we used a survey instrument created by Dr. Gregg Warnick that evaluated both quantitative and qualitative aspects of engineering global competency, and offered insights into the relative importance that employers put on these competencies [20]. We investigated the following exploratory research questions regarding global competency for newly graduated engineering students from the perspective of an employer:

(1) What global competencies are most highly valued by those directly involved in hiring engineering graduates?
(2) How do contextual factors of employers (e.g. gender, job title, and industry segment) affect the views and attitudes of global competency traits?

3.2 Instruments used

In this study we used the survey items developed by Warnick and added three additional items to the survey (marked in italics) as shown below. The survey items were developed after a meta-review of over 50 papers related to global competency [20]. Warnick's instrument was then refined with focus groups comprised of industry subject matter experts and faculty including Dr. Alan Parkinson the Dean of the College of Engineering at Brigham Young University (BYU). The survey was piloted to 15 BYU engineering alumni with a diverse set of experiences and improvements to the instrument were made as a result of feedback. During the instrument development phase, the competencies and their associated definitions were established. This survey was then sent to $\sim$2800 mechanical engineering alumni from BYU in May of 2010. We identified the 8 skills of 15 that were directly related to global competencies versus general technical skills. The resulting 8 skills (plus the three additional competencies added by the authors) were rated by these alumni on a 3-point Likert scale from "Unimportant/Little Importance (1) to Very Important (3)" and are listed in Table.

The last three skills were added as a result of their importance as identified from a variety of sources. First and foremost, these skills were identified by a formal survey effort deployed by the Industry-University-Government Roundtable for Enhancing Engineering Education (IUGREEE) [25]. More specifically the motivation for adding *designing a system, solution, or process to meet desired needs*

Table 1. Engineering Global Competency Items and Definitions

Competency	**Definition**
Exhibit a global mindset	Establishes self-awareness, understands cultural norms and expectations, and realizes that they are part of a global world
Appreciate and understand different cultures	A developed awareness, appreciation, and understanding of, as well as adaptability to diverse cultures, perceptions, and approaches with an ability to interact with people from other cultures and countries
Demonstrate world and local knowledge	Understands the major currents of global change and its implications and demonstrate knowledge within a global and comparative context
Communicate cross-culturally	Interacts with and understand people from different cultures and recognize the importance of both appropriate verbal and nonverbal communication including the ability to communicate and interact in a globally interdependent world
Speak more than one language including English	Communicates in the international business language of English both orally and in writing, and the ability to speak another language
Understand international business, law, and technical environment	Understands the different cultural contexts of how business, law, engineering and technology might be approached and applied and the implications of each within an international environment
Live and work in a transnational engineering environment	An ability and awareness to live and work effectively in international settings
Work on international teams	Collaborates and contributes professionalism in multicultural work environments either in person or in geographically distributed teams with person of different cultures and linguistic backgrounds where diverse ways of thinking, being, and doing are the basis of practice.
Design a system, solution, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health/safety manufacturability, and sustainability	Demonstrates the attainment of this skill as defined by ABET 2000 Criterion 3 outcome C
Work on problems with a global scale/scope	Appreciates the increase in complexity of projects whose boundaries impact more than one country
Identify risks and formulate solutions/plans to mitigate risks	Integrates risk management principles and create a plan during process or product development

within realistic constraints stemmed from the educational outcome c as defined by ABET, *working on problems with a global scale/scope* is directly related to outcome h, and *identifying risks and formulate solutions/plans to mitigate risks* is a sub-skill of ABET outcome d (as defined in the IUGREEE study). Though the ability to conduct risk management is not an ABET outcome, the importance of risk management in all engineering disciplines has been widely reported on an international scale [26], [27]. Thus we felt there was sufficient support and relevance for adding this skill to our assessment survey.

3.3 Selection, recruitment of respondents, and study population

The survey was distributed to alumni of the two institutions that have contributed to this research objective, Brigham Young University (BYU) and North Carolina State University (NCSU). These institutions were chosen for this study given the accessibility of alumni data and the degree to which its alumni work internationally. NCSU is a public, coeducational research university located in the South East portion of the United States. NCSU has a current enrollment of roughly 6,000 engineering undergraduate students, and 2,300 engineering graduate students. BYU is one of the largest private universities within the world and is located in the Western portion of the United States. BYU has a current enrollment of roughly 3,600 engineering and technology students (both undergraduate and graduate). The survey was directed at selected alumni of these two institutions. The engineering disciplines that were polled were Chemical Engineering, Electrical/Computer Engineering, Industrial/Manufacturing Engineering, and Mechanical Engineering since both institutions offer these degree programs.

To have a diverse set of study participants, by both years of experience and discipline, we solicited participants by contacting alumni from NCSU's alumni database from 1980–2011 from the following departments: Mechanical, Electrical & Computer, Industrial, and Chemical Engineering. For BYU, we contacted graduates from BYU's alumni database who graduated from 1980 to 2011 in Electrical and Computer Engineering, Manufacturing Engineering Technology, and Chemical Engineering (Mechanical Engineering alumni were contacted in Warnick's original research on this topic and therefore not used in this study). We used Qualtrics to administer the survey via email; and participants consented to the use of this data for research purposes as required by IRB.

The survey was distributed to 21,208 engineering alumni, with 882 respondents, resulting in a 4.2% response rate. Out of the engineering alumni who responded, 442 (48%) were directly involved in recruiting or making hiring decisions for new engineers. It is this subset of respondents that were the primary focus of this paper. It is believed that, in assessing the importance of engineering global competency, we must first start with those alumni who are directly involved in hiring newly graduated engineers. The statistics below, as well as the analysis that follows, was developed from this subset of the total sample.

4. Preliminary results and analysis

4.1 Profile of respondents

Among various different types of questions, study respondents were asked to indicate if they spoke a foreign language, and of the respondents involved in hiring decisions, 167 (47%) said yes and 190 (53%) said no. Of these same respondents, 97% are employed at least part time, 100% work for companies that conduct business internationally, and 86% have worked in a global environment during part of their careers.

The profile data also showed the majority of survey respondents were employed by larger companies, with 64% of respondents employed by companies with annual revenue exceeding $1 billion. In terms of graduation year, 147 (33%) graduated between 1980 and 1989, 146(33%) graduated between 1990 and 1999, and 149 (34%) graduated between 2000 and 2011. The majority of respondents work in the areas of "technology" or "manufacturing", with a fair amount of respondents choosing "other" as the best categorization of their field of work. Finally, over 54% of the respondents of the survey who are involved in hiring decisions indicated that they spend time with colleagues located in another country more than 25% of the time. See Table 2 for a detailed summary of the relevant contextual factors for those directly involved in hiring. We chose to include both industry segment and academic discipline as contextual factors in this analysis. This was justified as the Pearson correlation between the two variables was very low and not significant ($\rho = 0.031$, $p = 0.632$). Therefore, industry segment and academic discipline should yield results independent of each other. Because the respondents were not forced to answer every question (and could choose to leave out personal information if desired), the counts for each contextual category did not match. However, because we leveraged the survey development by Warnick [20], validation was not necessary for this part of the study.

4.2 Relative importance of engineering global competencies

There has been growing interest in exploring how engineering alumni, especially those directly involved in hiring newly graduated engineers, value certain skills, attitudes, and knowledge in terms of their importance in a global work environment. It was also a fruitful and relevant exercise to investigate which contextual factors affect these viewpoints in turn. To measure the importance that employers place on these global competencies, the following survey question was posed to the respondents:

- *Rate how important it is for engineers hired by a company who will either work immediately or eventually in a global environment to have the following skills.*

The 11 global competencies the respondents were asked to evaluate are described in detail in the Methodologies section above. The survey question had the respondents rate the different competencies on a 3-point importance Likert scale, with the following coding:

- 1 = Unimportant/Little Importance
- 2 = Moderately Important
- 3 = Important/Very Important

Table 3 displays the descriptive statistics of the relative importance ratings of each global competency, ranked from highest rated competencies to lowest rated competencies in terms of importance.

In addition to rating the importance of the various global competencies developed by [20], we also conducted an analysis to determine if there was significant associations between the value of these competencies and certain contextual factors of the respondents. How much influence do the different contextual factors have on the relative importance of global competencies? The 6 factors used in the study were Gender, Academic Discipline, Percentage of Time Spent Working Internationally, Job Title, Company Size, and Industry Segment. A Pearson Chi-Squared Test for Association was conducted to test for significant relationships

Table 2. Sample Size Breakdown of Predictor Variables for Those Directly Involved in Hiring

Gender	Sample Size	Percentage
Female	45	12.64
Male	311	87.36
Total	356	100.00
Academic Discipline	**Sample Size**	**Percentage**
Chemical Engineering	74	30.96
Electrical Engineering	96	40.17
Industrial Engineering	40	16.74
Mechanical Engineering	29	12.13
Total	239	100.00
Percentage of Time Working Internationally	**Sample Size**	**Percentage**
Less than 25%	144	46.45
Between 25-49%	101	32.58
Between 50-74%	49	15.81
Between 75-100%	16	5.16
Total	310	100.00
Job Title	**Sample Size**	**Percentage**
Senior Leadership/Executive	109	24.66
Manager	130	29.41
Engineer/Technical	184	41.63
Other	19	4.30
Total	442	100.00
Company Size	**Sample Size**	**Percentage**
Less than 1,000 employees	94	21.27
1,000 – 10,000 employees	105	23.76
More than 10,000 employees	243	54.97
Total	442	100.00
Industry Segment	**Sample Size**	**Percentage**
Aerospace	26	5.88
Automotive	14	3.17
Construction	4	0.09
Consulting	32	7.23
Consumer Products	30	6.79
Government/Military	20	4.52
Manufacturing	104	23.53
Media/Entertainment	4	0.09
Medical/Biotech	33	7.47
Technology	110	24.89
Other	65	14.71
Total	442	100.00

Table 3. Descriptive Statistics of Importance of Engineering Global Competencies (SD = Standard Deviation)

Ability to:	**Valid**	**Mean**	**SD**
Identify Risks and Formulate solutions/plans to mitigate risks	361	2.63	0.54
Design a system, solution, or process to meet desired needs within realistic constraints	360	2.59	0.60
Appreciate and understand different cultures	359	2.48	0.64
Work on international teams	362	2.40	0.68
Communicate cross-culturally	362	2.39	0.66
Work on problems with a global scale/scope	360	2.27	0.68
Exhibit a Global Mindset	363	2.26	0.68
Live and work in a transnational engineering environment	358	2.09	0.73
Demonstrate world and local knowledge	360	1.94	0.64
Understand international business, law, and technical elements	363	1.65	0.66
Speak more than one language including English	359	1.55	0.65

between two categorical variables. An alpha level of $\alpha = 0.05$ was used throughout the statistical analysis. All methodological assumptions were met. Namely, there was a sufficiently large sample size and expected cell count for each contextual factor category and independent observations. Table 4 provides a summary of the significant findings from chi-squared test analysis.

Table 4. Significant results from Pearson Chi-Squared Tests

Contextual Factor	Significantly Associated Item	Pearson Chi-Squared Test Statistic (df)	p-value	Sample Size (n)
Gender	Demonstrate world and local knowledge	χ^2 (2) = 10.18	0.006	353
Academic Discipline	*No significant associations with any engineering global competency item*			
Percentage of Time Spent Working Internationally	Exhibit a global mindset	χ^2 (6) = 22.64	0.001	310
	Communicate cross culturally	χ^2 (6) = 17.55	0.007	309
	Live and work in a transnational engineering environment	χ^2 (6) = 15.71	0.015	305
	Work on international teams	χ^2 (6) = 37.91	<0.001	309
	Work on problems with a global scale/scope	χ^2 (6) = 18.91	0.004	307
Job Title	Exhibit a global mindset	χ^2 (6) = 12.77	0.047	363
	Demonstrate world and local knowledge	χ^2 (6) = 20.32	0.002	360
	Speak more than one language, including English	χ^2 (6) = 18.15	0.006	359
	Live and work in a transnational engineering environment	χ^2 (6) = 13.70	0.033	358
Company Size	Design a system, solution, or process to meet desired needs with realistic constraints	χ^2 (4) = 11.77	0.019	360
	Speak more than one language, including English	χ^2 (4) = 12.34	0.015	359
	Understand international business, law, and technical elements	χ^2 (4) = 12.71	0.013	363
	Work on problems with a global scale/scope	χ^2 (4) = 10.11	0.039	360
	Identify risks and formulate solutions/plans to mitigate risks	χ^2 (4) = 11.85	0.018	361
Industry Segment	Speak more than one language, including English	χ^2 (20) = 49.97	<0.001	359
	Understand international business, law, and technical elements	χ^2 (20) = 36.84	0.012	363
	Work on international teams	χ^2 (20) = 34.42	0.039	362
	Identify risks and formulate solutions/plans to mitigate risks	χ^2 (20) = 40.92	0.004	361

4.3 Correlation between frequency of significant associations and mean importance rating

In addition to the rating of engineering global competencies, and the contextual factors that help shape the pattern of importance among the employers, we analyzed the frequency of the engineering global competency items that had significant associations with contextual factors of employers. We investigated whether certain global competencies are more affected by contextual factors of employers and whether there was any correlation between the global competencies that are highly effect by contextual factors and how employers rate these competencies in terms of importance when making hiring decisions. This type of comparison helped uncover the details behind the various patterns of importance found above, and further describes the nature of the mean importance ratings for each global competency. Fig. 1 displays this comparison.

A Spearman's rank-order correlation was calculated between the frequency of significant associations for each global competency and the mean importance rating. The Spearman's rank-order correlation, measured by ρ (rho), measures the strength of association between two ranked variables. It is also the nonparametric version of the Pearson product-moment correlation. There was a significantly high negative correlation between the frequency of significant associations per global competency item and that item's mean importance rating according to the employers, ρ = –0.639, p = 0.034.

In the analysis above, we found that engineering global competency items that are rated higher by employers in terms of their importance tend to have fewer significant associations with contextual factors. On the other hand, the global competency items that are rated lower by employers tend to have more significant associations with contextual factors. It seems as though the competencies regarded as "most important" (i.e. appreciate and understand different cultures, design a system, solution or process to meet desired needs within realistic constraints, and communicate cross-culturally) are not as affected by employer variables such as company size and job title, meaning that the top global competencies are more universally regarded as being "vital" when making hiring decisions. Compare this with the competencies deemed "less important, which are affected more by these employer variables. For example, the competencies such the ability to *understand international business, law, and technical elements* and *the ability to speak more than one language including English* while regarded as the least important of the 11 global competencies, have less consensus on the importance rating due to the myriad of contextual factors. In the end, these factors of the employer and respective company ultimately determine how much importance is placed on these particular items. The responsibility is then placed on engineering programs to better understand the variation of global competency views among employers and to become familiar with the employer landscape before designing engineering curricula.

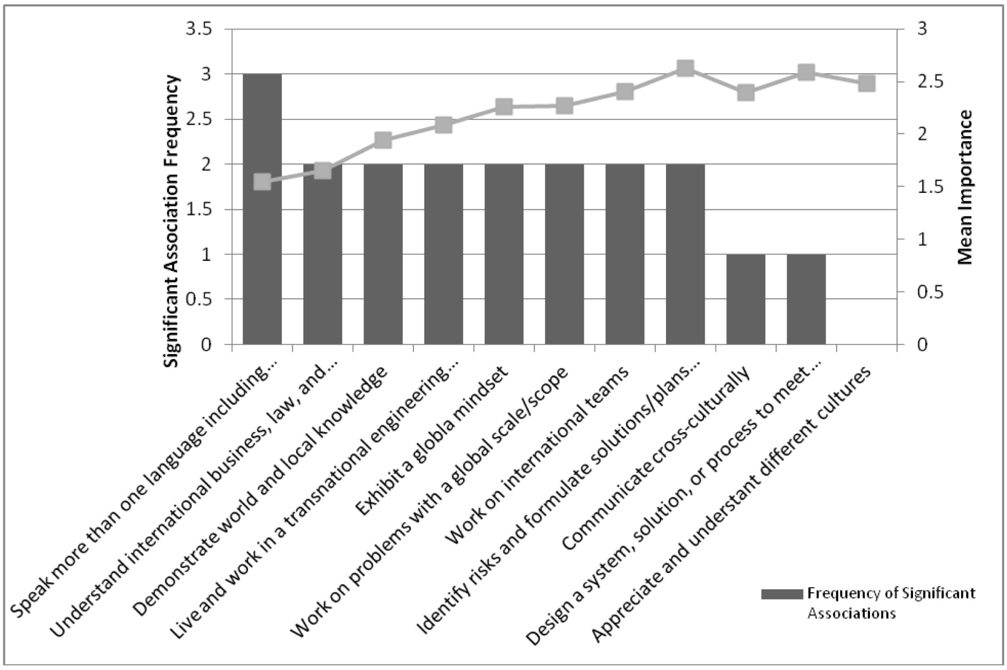

Fig. 1. Correlation between frequency of significant associations and mean importance rating of global competency items.

4.4 Following-up chi-squared tests—Pearson standardized residuals

Since Pearson Chi-Square Tests only tests for associations between 2 variables and provides little information about the nature or strength of the association, the next step was to calculate the *Pearson Standardized Residuals* for each cell in the statistically significant contingency tables. A cell-by-cell comparison of observed and estimated expected frequencies helps show the nature of the dependence [28]. Under the null hypothesis, H_0, that the 2 variables are independent (no association), the Pearson Standardized Residuals will have a standard normal distribution, with a mean of 0 and variance of 1.

(1) A standardized residual that is greater than 1.96 (or 2 as common convention) indicates that the number of cases in that cell is *significantly larger* than would be expected if the null hypothesis were true, with a significance level of 0.05.
(2) A standardized residual less than –1.96 (or 2 as common convention) indicates that the number of cases in that cell is *significantly smaller* than would be expected if the null hypothesis were true.

An analysis of these standardized residuals allowed us to hone in on what cells provided most of the contribution to the large chi-square test statistic for a particular table. The formula used to calculate the Pearson Standardized Residuals is in Appendix A.

4.4.1 Gender

A categorical comparison was conducted for the importance the ability to *demonstrate world and local knowledge*, by gender (male or female). According to the table of standardized residuals, the significant association is characterized by how respondents rated this item as moderately important and important/very important across gender. For example, there was a significantly fewer amount of males who rated this global competency item as ''important/very important'' than would be expected if Gender and the importance of the ability to demonstrate world and local knowledge were independent of each other. Similarly, a significantly larger amount of females rated this item as ''important/very important'' than would be expected under H_0. Generally speaking, females value this global competency item with more regard when compared to males. Table 5 provides more detailed summary of the standardized residuals for this item.

4.4.2 Academic discipline

When conducting Pearson Chi-Squared tests on academic discipline and the global competency items (see Table 4), there were no significant associations between this contextual factor and any of the items on the survey. Therefore, the standardized residuals were not analyzed. The results from this support the findings from [23, 24], which assert that there is a different overall pattern of importance among the competencies for different jobs and professional fields, but not necessarily academic

Table 5. Pearson Standardized Residuals, r_{ij}, for Gender

	Gender	
Demonstrate world and local knowledge	**Male**	**Female**
Unimportant/Little Importance	–1.3	1.3
Moderately Important	3.0	–3.0
Important/Very Important	–2.5	2.5

disciplines. However, it does contrast the findings from [21, 22], which emphasizes the role of academic discipline more strongly in relation to the importance of competencies. This difference could be due to the difference in population samples (employers vs. students) and in the nature of the competencies themselves.

4.4.3 Percentage of time spent working internationally

A categorical comparison was conducted for importance of the ability to *exhibit a global mindset, the ability, communicate cross culturally, live and work in a transnational engineering environment, work on international teams* and *work on problems with a global scale/scope*, by the percentage of time spent working internationally (Less than 25%, Between 25–49%, Between 50–74%, Between 75–100%). According to the table of standardized residuals, the significant association is characterized by how respondents rated this item among all importance levels across the percentage of time spent working internationally. In general, those employers who have spent less than 25% of their time working internationally responded to these items "important/very important" in significantly lower counts than would be expected under H_0 (that the time spent working internationally is independent of the importance ratings of global competencies). The five items showed a similar pattern of difference, with employers who have spent substantial amounts of time working internationally viewing the above global competency items as more important than those who have had less time working internationally. Table 6 in Appendix B provides an example how employers responded to these item by percentage of time spent working internationally, represented by the standardized residuals.

4.4.4 Job title

A categorical comparison was conducted for importance of the ability *to exhibit a global mindset, demonstrate world and local knowledge, speak more than one language including English,* and *live and work in a transnational engineering environment,* by employer job title (Senior Leadership/Executive, Manager, Engineer/Technical, Other). There were significant standardized residuals for how respondents rated these on all importance levels across the job titles. For example, the standardized residuals for *speak more than one language, including English* told us that, in general, Senior Leadership/Executives view this item as "unimportant/little importance" in much lower numbers than would be expected under H_0. Likewise, this same item is seen, as "unimportant/little importance" in much greater numbers than would be expected under H_0 for Engineers/Technical. In general, the higher up in the company the respondent was, the more likely they value the acquisition of a second language. Similar patterns were found for the other three items, observing that employers with more advanced job titles give more importance to these engineering global competencies. Table 7 in Appendix C provides more detail of how employers responded to this item by job title, represented by standardized residuals.

4.4.5 Company size

A categorical comparison was conducted for importance of the ability to *design a system, solution, or process to meet desired needs with realistic constraints, speak more than one language including English, understand international business, law, and technical elements, work on problems with a global scale/scope* and *identify risks and formulate solutions/plans to mitigate risks,* by employer company size (<1,000 employees, 1,000 to 10,000 employees, >10,000 employees). There were significant standardized residuals for how respondents rated these on all importance levels across company size. For example, the number of employers who work for companies with <1,000 employees who rated *the ability to identify risks and formulate solutions/plans to mitigate risks* as "important/very important" is significantly lower than would be expected under the H_0. Similar patterns were found among the other items and in general, the smaller companies tended to not view these global competencies as highly as the largest companies (>10,000 employees), with the exception of *the ability to speak more than one language, including English*.

The number of employers who work for companies with <1,000 employees who rated this item as "important/very important" is significantly higher than would be expected under H_0 and the number of employers who work for companies with > 10,000 employees who rated this item as "important/very important" is significantly lower than would be expected under H_0. In general, we observed the pattern of employers who work for larger companies (in terms of number of employees) give more importance to the engineering global competencies when making hiring decisions, with the exception of the ability to speak a foreign language. The initial impression from our study is that, while larger companies may have a more expansive global footprint and may have substantially more work in global business, the employers from these same companies don't necessarily place great importance on second language acquisition. This result can and should be explored further to help students prepare themselves to work in a global environment post-graduation. Table 8 in Appendix D provides more detail of how employers responded to these items by company size, represented by standardized residuals.

4.4.6 Industry segment

A categorical comparison was conducted for importance of the ability *to speak more than one language including English, understand international business, law, and technical elements, work on international teams* and *identify risks and formulate solutions/plans to mitigate risks,* by employer industry segment (Aerospace, Automotive, Construction, Consulting, Consumer Products, Government/Military, Manufacturing, Media/Entertainment, Medical/BioTech, Technology, and Other). Since many of the categories within industry segment have very small sample sizes, the focus of Pearson standardized residual analysis are on those industry segments with greater number of employers, which includes Aerospace, Consulting, Consumer Products, Manufacturing, Medical/BioTech, and Technology. There were significant standardized residuals for how respondents rated these items on all importance levels across industry segment. For example, the amount of employers who work in the aerospace industry who rated *the ability to understand international business, law, and technical elements* as "important/very important" is significantly higher than would be expected under H_0 and the amount of employers who work in the manufacturing industry who rated this item as "important/very important" is significantly lower than would be expected under H_0 . Another finding below suggests that those employers who work in the Technology field view "*the ability to understand international business, law, and technical elements* as less important in greater numbers than expected under H_0, but view *the ability to work on international teams* as less important in fewer numbers than expected under H_0. However, there weren't any emerging themes or patterns regarding industry segment and how employers view the importance of engineering global competencies. Certain global competency items applied more to certain industries, and less to others, which is the hypothesized reason for categorical differences. It is posited that many of the true differences among industry segment in the study might not be found due to a low sample size per category, causing a lack of statistical power. Table 9 in Appendix E provides more detail of how employers responded to these items by industry segment, represented by standardized residuals.

5. Summary and discussion

Over the past decade research on identifying engineering global competencies has laid a foundation for additional work that will provide institutions of higher education with a deeper understanding of the skills that should be developed during a student's undergraduate education. We built upon this work by developing a survey instrument that was deployed to engineering alumni from NCSU and BYU's departments of Chemical, Electrical/Computer, Industrial/Manufacturing, and Mechanical engineering who are involved in the hiring process of new engineering graduates. The goal of our survey was to develop a quantitative analysis framework to answer two research questions. First, we were interested in measuring "What global competencies are most highly valued by those directly involved in hiring engineering graduates?" By answering this question we are able to (at an aggregate level) assess which competencies are most valued by industry. We presented descriptive statistics that show the mean rating across the 11 competencies as rated by engineers involved in the hiring process. We can take these results and prioritize initiatives that support the acquisition of these skills in our engineering undergraduates. We hypothesized that the importance of these skills varies by characteristics of the study participants. This hypothesis led to our second research question: "How do contextual factors of employers (e.g. gender, job title, and industry segment) affect the views and attitudes of global competency traits?" We analyzed this hypothesis by firstly formulating a Pearson Chi-Squared for Association between factors and competencies and secondly by a Pearson Standardized Residuals analysis to describe the distribution of the ratings across the Likert scale. By exploring the relationship between these factors and the importance ratings, we were able to identify significant associations that led to a more comprehensive view of how these factors impact the value placed on these skills.

This study's limitations have provided direction for future work. Specifically the analysis presented in this paper does not incorporate qualitative methods such as in-depth interviews which could further frame the quantitative results. Expanding the respondent demographics to include hiring managers educated and working outside of the United States would allow us to compare between country factors.

6. Conclusions

RQ 1: What global competencies are most highly valued by those directly involved in hiring engineering graduates?

Our results show that the top five valued global competencies were the ability to: (1) Identify Risks and Formulate solutions/plans to mitigate risks, (2) Design a system, solution, or process to meet desired needs within realistic constraints (3) Appreciate and understand different cultures, (4) Work on international teams, (5) Communicate cross-culturally. The relative ratings of these competencies provide the necessary backdrop in order to delve deeper into the rationale for these rankings as they pertain to contextual factors of the employers. These findings are consistent with other research which supports the notion that skills beyond technical competence are critical to being a successful globally competent engineer. Possessing engineering technical competencies is essential if one wants to be employed as an engineer, regardless of the nature of the environment. However, global competencies are critical as well and engineering graduates should focus on the developing these kind of competencies, specifically the ability to appreciate and understand different cultures, the ability to work on international teams, and the ability to communicate cross-culturally. We explored the relationship between employer characteristics and importance of global competencies in our second research question.

RQ 2: How do contextual factors of employers (e.g. gender, job title, and industry segment) affect the views and attitudes of global competency traits?

The results of our study indicated that not all engineers who are involved in the hiring process view the skills required to be a successful global engineer equally. We considered 6 contextual factors that we hypothesized would influence the importance placed on global competencies, they are: Gender, Academic Discipline, Percentage of Time Spent Working Internationally, Job Title, Company Size, and Industry Segment. A Pearson Chi-Squared Test for Association and a Pearson Residuals Analysis was conducted to test for significant relationships between two categorical variables. Gender was a significant predictor of the importance of "demonstrating world and local knowledge" and female respondents valued this competency higher than males. We found that significant relationships between the competencies did not exist between Academic Disciplines and potential reasons for this are discussed in Section 4.4.2. The respondents who spent more time working internationally rated five of the competencies higher than those who spent less time working internationally. This result supports the notion that students and academia should be aware of the requirements of their students' future workplace. If the engineer is interested or destined to work in a global company then supporting the acquisition of these competencies could be critical to their success as a practitioner. Similarly, the results for Job Title, Company Size, and Industry Segment reveal that workplace characteristics and career experience (as measured by job title) influence the competencies that are highly valued. Another interesting result was revealed by calculating the Spearman's rank-order correlation to determine if there was a high and significant pattern between the frequency of the global competency items with signficant associations with contextual factors and mean importance of those items. The global competency items that were deemed "most important" tended to have less signficant associations with the factors which imply they are universally important. Conversely, the items that were deemed "less important" tended to have more signficant associations with the factors. Together these results provided a deeper understanding of industry expectations which is not a "one size fits all" perspective and these expectations should be reflected in the education of future engineers.

The significance of these findings lies in the groundwork they lay in sparking additional research to further characterize and explore how engineers view the importance of global competency. An understanding of student career goals and workplace environment are critical in prioritizing the competencies that will be emphasized by places of higher education. Future qualitative research could complement the results of this research by providing explanations to the differences in perspectives revealed by this study. Engineering education researchers must continue to explore how the differences as identified by the analysis of contextual factors can be linked to curriculum and international programming developed by universities. Furthermore, future reseasrch is needed in order to develop a deeper understanding of how the preparedness of our graduates aligns against these expectations. This work is a critical next step to understand and reduce the gap between engineering students' global competency and professional expectations by those employ the engineering workforce of the future.

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Appendix A

Agresti notes that as the degrees of freedom for the chi-square test increases (with increasing number of rows and/or columns in the contingency table), it will be increasingly likely that at least one of the cells will have a large standardized residual by chance alone [28]. For the null hypothesis that a contextual factor and an importance rating of a global competence item are independent, a standardized residual, r_{ij} that is asymptotically standard normal results in the following equation, described by Agresti in [28],

$$r_{ij} = \frac{n_{ij} - \widehat{\mu_{ij}}}{\sqrt{\widehat{\mu_{ij}}(1 - p_{i+}) * (1 - p_{+j})}}$$

where,

n_{ij} = the observed cell count from row i and column j.
$\widehat{\mu_{ij}}$ = the expected cell count from row i and column j under H_0.
p_{i+} = the marginal probability of row i.
p_{+j} = the marginal probability of column j.

Cells in the contingency tables that have significantly high or low standardized residuals are highlighted in gray, as these cells help describe the nature of the significant association. Only the relevant information (Pearson standardized residuals) is presented in the tables below.

Appendix B

Table 6. Pearson Standardized Residuals, r_{ij}, for Percentage of Time Spent Working Internationally

Exhibit a global mindset	**Percentage of Time Spent Working Internationally**			
	Less than 25%	Between 25–49%	Between 50–74%	Between 75–100%
Unimportant/Little Importance	1.5	–1.8	0	0.3
Moderately Important	3.0	–0.1	–2.9	–1.9
Important/Very Important	–4.0	1.1	3.0	1.7
Communicate cross culturally	Less than 25%	Between 25–49%	Between 50–74%	Between 75–100%
Unimportant/Little Importance	2.7	–2.1	–0.4	–1.2
Moderately Important	1.4	0.6	–1.7	–1.7
Important/Very Important	–2.8	0.5	1.9	2.3
Live and work in a transnational engineering environment	Less than 25%	Between 25–49%	Between 50–74%	Between 75–100%
Unimportant/Little Importance	3.3	–1.7	–1.0	–2.0
Moderately Important	–0.5	0	–0.5	2.0
Important/Very Important	–2.1	1.4	1.3	–0.4
Work on international teams	Less than 25%	Between 25–49%	Between 50–74%	Between 75–100%
Unimportant/Little Importance	4.8	–3.4	–1.5	–1.1
Moderately Important	2.7	–1.6	–1.7	0
Important/Very Important	–5.1	3.3	2.4	0.6
Work on problems with a global scope	Less than 25%	Between 25–49%	Between 50–74%	Between 75–100%
Unimportant/Little Importance	3.8	–2.8	–1.5	0
Moderately Important	0.5	0.1	–0.4	–0.7
Important/Very Important	–3.1	1.8	1.4	0.7

Appendix C

Table 7. Pearson Standardized Residuals, r_{ij}, for Job Title

Exhibit a global mindset	**Percentage of Time Spent Working Internationally**			
	Senior Leadership/ Executive	Manager	Engineer/ Technical	Other
Unimportant/Little Importance	–2.2	0.1	2.2	–0.6
Moderately Important	0.5	–0.3	0.5	–1.8
Important/Very Important	1.1	0.2	–2.0	2.3
Demonstrate world and local knowledge	Senior Leadership/ Executive	Manager	Engineer/ Technical	Other
Unimportant/Little Importance	–3.5	1.2	2.5	–1.4
Moderately Important	3.3	–0.4	–2.3	–0.4
Important/Very Important	–0.3	–0.7	0.2	2.0
Speak more than one language, including English	Senior Leadership/ Executive	Manager	Engineer/ Technical	Other
Unimportant/Little Importance	–3.5	1.2	2.5	–1.7
Moderately Important	2.3	–1.1	–1.5	1.2
Important/Very Important	2.1	–0.3	–2.0	0.8
Live and work in a transnational engineering environment	Senior Leadership/ Executive	Manager	Engineer/ Technical	Other
Unimportant/Little Importance	–0.8	1.7	–0.2	–1.9
Moderately Important	1.0	–2.2	1.5	–0.9
Important/Very Important	–0.4	0.8	–1.4	2.7

Appendix D

Table 8. Pearson Standardized Residuals, r_{ij}, for Company Size

Design a system, solution, or process to meet desired needs with realistic constraints	**Company size**		
	<1,000 employees	1,000 to 10,000 employees	>10,000 employees
Unimportant/Little Importance	1.4	0.3	–1.5
Moderately Important	2.2	0.9	–2.6
Important/Very Important	–2.8	–1.0	3.2
Speak more than one language, including English	<1,000 employees	1,000 to 10,000 employees	>10,000 employees
Unimportant/Little Importance	–1.3	1.1	0.2
Moderately Important	–0.2	–1.7	1.5
Important/Very Important	2.7	0.9	–3.0
Understand international business, law, and technical elements	<1,000 employees	1,000 to 10,000 employees	>10,000 employees
Unimportant/Little Importance	–1.8	1.1	0.6
Moderately Important	3.2	–1.8	–1.2
Important/Very Important	–2.2	1.0	1.0
Work on problems with a global scale/scope	<1,000 employees	1,000 to 10,000 employees	>10,000 employees
Unimportant/Little Importance	1.2	–0.6	–0.6
Moderately Important	2.3	–0.7	–1.3
Important/Very Important	–3.2	1.1	1.7
Identify risks and formulate solutions/plans to mitigate risks	<1,000 employees	1,000 to 10,000 employees	>10,000 employees
Unimportant/Little Importance	1.2	–1.1	–0.1
Moderately Important	2.7	0.5	–2.7
Important/Very Important	–3.1	–0.1	2.7

Appendix E

Table 9. Pearson Standardized Residuals, r_{ij}, for Industry Segment

Speak more than one language, including English	**Industry Segment**					
	Aerospace	Consulting	Consumer Products	Manufacturing	Medical/ BioTech	Technology
Unimportant/Little Importance	1.5	–2.0	0.3	1.7	1.6	0.6
Moderately Important	–1.2	1.8	0.2	–0.6	–1.4	–0.9
Important/Very Important	–0.6	0.3	–0.8	–2.0	–0.5	0.5
Understand international business, law, and technical elements	Aerospace	Consulting	Consumer Products	Manufacturing	Medical/ BioTech	Technology
Unimportant/Little Importance	–1.9	–1.8	0.5	1.0	–0.7	2.6
Moderately Important	0.1	2.2	–1.1	0.2	0.9	–2.3
Important/Very Important	2.9	–0.6	1.0	–2.1	–0.3	–0.5
Work on international teams	Aerospace	Consulting	Consumer Products	Manufacturing	Medical/ BioTech	Technology
Unimportant/Little Importance	0.5	–1.3	–1.1	0.8	0.7	–2.3
Moderately Important	0.3	–0.6	–0.4	0.4	–0.1	0.2
Important/Very Important	–0.6	1.4	1.1	–0.8	–0.4	–0.9
Identify risks and formulate solutions/plans to mitigate risks	Aerospace	Consulting	Consumer Products	Manufacturing	Medical/ BioTech	Technology
Unimportant/Little Importance	1.9	–1.0	–0.9	–0.5	1.1	–1.2
Moderately Important	–2.6	0.1	1.1	–0.6	0.7	0.6
Important/Very Important	1.9	0.3	–0.8	0.7	–1.0	–0.1

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