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Using Concept Mapping to Investigate Engineering Students' Global Workforce Perceptions

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INTRODUCTION

Over the last two decades the workplace has changed dramatically, requiring a workforce that crosses borders and engineering professionals who can work globally by interfacing with different cultural backgrounds. Business is being conducted on a global scale and the companies that flourish in this economy understand the significance of these forces on their livelihood, and through this, recognize the importance of employing people with global skills in order to succeed (Heiden, 2012). Multinational corporations are major stakeholders in the preparation of undergraduates. Industry-academic partnerships can help sustain a steady flow of globally prepared engineering graduates ready to solve 21st century problems. With 51 corporations representing 70% of world trade, future engineering graduates will have to increasingly develop their global competencies to succeed (Parkinson, 2009). Accreditation bodies, national engineering organizations, and government agencies have also recognized the importance of preparing students to be successful in today's globally interconnected world (McNeill, 2010). In 2000, ABET Inc. introduced a global element into their EC2000 criteria for undergraduate engineering programs. Criterion 3(h) states that "Engineering programs must demonstrate that their students attain the following outcome: the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context" (ABET, 2013).

However, research has suggested that the capability of engineering graduates does not meet the expectations of industry employers (May & Strong, 2006; Sageev & Romanowski, 2001; Walther & Radcliffe, 2007). It is posited that a major factor of this difference between academia and industry could be global workforce perceptions. Specifically, it is unclear whether what employers expect in regards to a globally prepared engineering graduate is being fostered in engineering curricula, or valued by the students themselves. A key step in preparing the next generation of engineering graduates is to better understand the gap that exists between industry global workforce expectations and students' global workforce perceptions. This study investigates this phenomenon.

In this study, a survey was administered to approximately 200 engineering students at a large university in the U.S., where 127 engineering students responded to the following open-ended question in a previous study: "What do you hope/expect to know upon completion of college to better prepare you to work successfully in a global engineering environment?" To identify emergent patterns in the responses, an integrative mixed methods approach called concept mapping was utilized. Concept mapping represents a systematic process that integrates structured group processes such as brainstorming, unstructured idea sorting, and rating tasks with multivariate statistical methods to produce a well-defined, quantitative set of results (Kane & Trochim, 2007).

The following research question is addressed: *What do engineering students hope/expect to know upon completion of college to better prepare them to work successfully in a global engineering environment?* Results from this study illustrate dimensions related to student global workforce perceptions and provide actionable information on future curriculum development in institutions of higher education for an increasingly globalized world.

LITERATURE REVIEW

Global Workforce Expectations

There have been numerous research studies that have focused on global workforce expectations, and defining global competencies of graduating engineers from an industry perspective. This research has shown that engineering graduates are not necessarily developing the skills required by industry (Allan & Chisholm, 2008; Jackson, 2010; Nair, Patil, & Mertova, 2009). Parkinson presented 13 dimensions of global competency deemed important by engineering educators and leaders in industry. Of utmost importance were the ability to appreciate other cultures, proficiency working in or directing a diverse team, cross-cultural communication, practical engineering experience in a global context, and the ability to deal with ethical issues arising from cultural differences (Parkinson, 2009). Warnick's study on the importance of global competencies for engineers working in global environments echoed these dimensions (Warnick, 2010). Work by the authors expanded on this research and found with a larger and more diverse sample of engineering employers that the ability to identify risks and formulate solutions; and the ability to design a system, solution, or process to meet desired needs within realistic constraints were also heavily valued by industry in global settings (Streiner, 2015).

As the engineering profession continues to become more global in nature, the range of career paths and roles becomes more diverse. Engineering educators are challenged to prepare students for this diversity of competency demands (Walther & Radcliffe, 2007). This results in the conflict of general engineering education verse preparation for specific industries, and consequently, a "competency gap" between academia and industry. While there have been studies that have investigated the gap between employers' perceptions and expectations of engineering graduates, (Catalano, 2012; Del Vitto, 2008; May & Strong, 2006; Zaharim, Omar, Basri, Liza, & Isa, 2009), and others probing engineering graduates perceptions on workforce preparation, (Martin, Maytham, Case, & Fraser, 2005; Passow, 2012; Tymon, 2013), there has yet to be a comprehensive study of students' global workforce perceptions, nor an analysis of the differences between employers and students in this regard. The work presented in this paper is part of a more comprehensive effort by the authors which aims to expand upon the previous research by triangulating employer global workforce expectations with engineering student perceptions. This effort is based on the hypothesis that the more aligned these expectations are, the more successful future engineering graduates will be in a globalized context. A necessary step in testing this hypothesis is to better understand the global workforce perceptions among engineering students, and the related dimensions.

Concept Mapping and Its Applications

Concept mapping is a participatory, mixed methods research approach that yields a conceptual framework for how a group views a particular topic (Trochim, 1989a). This method directly involves participants and balances group consensus with individual contributions (Kane & Trochim, 2007). The output of the concept mapping methodology is a stakeholder-authored visual diagram that shows the relationship between ideas that are taken from qualitative studies (e.g., Delphi studies or interviews). An advantage of concept mapping is that it can be implemented as a mixed methods approach, integrating group processes such as brainstorming and unstructured sorting with multivariate statistical methods of multidimensional scaling and hierarchical cluster analysis (Schröter, Coryn, Cullen, Robertson, & Alyami, 2012). This approach allows researchers to quantify the strength of the relationships between concepts as well as integrate rating systems (e.g., importance and confidence) to produce additional visualizations such as pattern matches and go-zones. From these visualizations researchers are able to construct a knowledge base around their research questions and prioritize recommendations (Kane & Trochim, 2007).

For the last two decades, concept mapping has been applied in many contexts, including public health (Burke et al., 2005), business (McLinden & Trochim, 1998), energy policy (Schröter et al., 2012), public school programs (Keith, 1989; Streeter, Franklin, Kim, & Tripodi, 2011) and many others (Rosas & Kane, 2012). Of particular relevance are applications of concept mapping within higher education, of which there are several. Trochim used concept mapping to help develop accreditation standards for graduate level programs in the U.S. (Trochim, 1996); Handley, Pappas, and Kander developed a collaborative consensus on learning goals and objectives among faculty of a university department (Handley, Pappas, & Kander, 2004); Abrahams examined the issues and barriers that prevent faculty from using technology in instruction using concept mapping (Abrahams, 2010); and Stoyanov et al. applied concept mapping to develop learning outcomes for an interdisciplinary module in medicine and engineering (Stoyanov et al., 2013). Work done by Poole and Davis shows the utility of concept mapping to measure and conceptualize student expectations in study abroad programs (Poole & Davis, 2006). To the best of the authors' knowledge, the work presented in this paper is the first application of Trochim's concept mapping in an engineering education context. Concept mapping is an efficient way of collecting information from diverse populations because ideas are usually generated in a group format. Students are key stakeholders in global engineering education programming and as such, are the focus of this concept mapping study.

METHODS

Concept mapping involves six major steps (Kane & Trochim, 2007; Trochim, 1989b), represented in Figure 1: (1) preparation, (2) generation of statements, (3) structuring of statements, (4) representation of statements, (5) interpretation of maps, and (6) utilization of maps. These steps are described in more detail in the following subsections. The university's Institutional Review Board approved this study (IRB #5650).

Step 1: Preparation

This study was conducted at a large, public, research intensive Southeastern University. The college of engineering is organized into 12 departments and is among the largest in the country. The college of engineering does not require international experiences in any of its 12 departments nor does it have an engineering focused international office.

Study Design: Concept mapping is a mixed methods approach to organizing "whose steps include brainstorming, statement analysis and synthesis, unstructured sorting of statements, multidimensional scaling and cluster analysis, and the generation of numerous interpretable maps and data displays" (Kane & Trochim, 2007). To prepare for the concept mapping process, the study population was identified as current undergraduate engineers. This study population was best positioned to address our research question which focused on undergraduate engineering students' global workforce perceptions. As part of a comprehensive survey that captured data on engineering students' educational backgrounds, global competencies, and international experiences, the authors also elicited information using the following open-ended question, administered using the Qualtrics online survey tool: "What do you hope/expect to know upon completion of college to better prepare you to work successfully in a global engineering environment?" The study population and concept mapping steps are discussed in more detail below.

Participants: The study population was broken into two cohorts. First, the open-ended question was sent to 200 undergraduate engineers via Qualtrics. A total of 127 students responded to the prompt (a response rate of 63.3%), resulting in 198 individual unitized statements that represent singular ideas; this student group will be referred to as Cohort #1. There was representation from each of the 12 departments with the majority of the participants with the larger departments participating with greater numbers. The participant details of this cohort are shown in Table 1.

The second part of the study was completed after the statements were collected. Since the students included in Cohort #1 may have been unavailable (a year had elapsed) we solicited a new set of participants from the same departments. Thus a proxy cohort of 25 undergraduate engineering students was leveraged for the concept mapping process and deemed to be a representative sample of our initial undergraduate group in Cohort #1. This

Table 1. Cohort #1 department participation summary

#	Department	Sample Size	%
1	Biological and Agricultural Engineering	19	15%
2	Biomedical Engineering	5	4%
3	Chemical and Biomolecular Engineering	30	24%
4	Civil, Construction, and Environmental	20	16%
5	Computer Science	10	8%
6	Electrical and Computer Engineering	7	6%
7	Forest and Biomaterials	1	1%
8	Industrial and Systems Engineering	8	6%
9	Material Science and Engineering	1	1%
10	Mechanical and Aerospace Engineering	14	11%
11	Nuclear Engineering	11	9%
12	Textile Engineering, Chemistry, and Science	2	2%
	Total	127	100%

new student group will be referred to as Cohort #2. Forty or fewer participants provides a good framework, ensuring a variety of opinions while stilling enabling good group discussion and interpretation (Kane & Trochim, 2007). However, the sample size does introduce the possibility for statistically tentative results. For this reason, statistical inference is avoided. Table 2 summarizes both cohorts' demographic information.

Table 2. Participant summary

Study Cohort	Academic Standing				Gender
	Freshman	***Sophomore***	***Junior***	***Senior***	***Male***
Cohort #1	8%	9%	31%	52%	68%
Cohort #2	4%	40%	32%	24%	52%

Step 2: Generation of Statements

The goal of this step was to gather the perspectives of our engineering student participants as a response to the prompt "What do you hope/expect to know upon completion of college to better prepare you to work successfully in a global engineering environment?" The responses were gathered online using Qualtrics as our survey tool and after completion of this step a comprehensive list of 198 individual, unitized statements were documented. The list was reviewed by the authors to obtain a list of unique ideas with only one idea represented in each statement. Further, the authors ensured that each statement was relevant to the study, was clear and understandable and reduced to a manageable number for subsequent steps. The list was also reviewed by 2 additional undergraduate engineers. The final refined list consisted of 100 statements.

Step 3: Structuring and Rating of Statements

The survey prompt described in Step 1 was deployed in March of 2014 which resulted in the need to form a proxy group to execute Steps 2 – 5. A second cohort of 25 undergraduate engineers were provided with physical packets that contained an instruction sheet, 100 index cards with the finalized list of statements, and other materials used to facilitate labelling the categories (e.g., rubber bands).

The students were first asked to group the statements into different piles based on perceived inter-relatedness of ideas, and asked to create a label for each pile. The students were informed that (1) all statements cannot be put into a single pile, (2) all statements cannot be put into their own separate piles, and (3) each statement can be placed in only one pile. The students were also asked to rate each statement using two measurable variables: importance and confidence. The authors noticed during the pilot that the typical verbiage of the confidence rating didn't make sense within the context of the statements. Some of the statements are skill-related (e.g. develop an open mind, communication skills) and others are experience-related (e.g. study abroad, international internships). As such, students were given the option to either rate there confidence in attaining that skill by graduation or confidence in being able to participate in that type of experience. The sorting and rating of the statements were piloted with 2 undergraduate engineers and the instructions were revised to provide better clarity. The rating statements were as follows:

1. Rate the importance of each statement on a five point scale, where '1' means "Not at all important", '3' means "Moderately important", and '5' means "Extremely important".

2. Rate each statement on a five point scale in terms of your confidence in (a) attaining that skill, or (b) participating in that experience, upon completion of college where '1' means "Not at all confident", '3' means "Moderately confident", and '5' means "Extremely confident".

The students were encouraged to think of the relative importance and relative confidence associated with each statement (i.e., all statements cannot be Extremely Important). The rating activity took place after the sorting activity was completed to disallow the grouping of statements based on the measurable variables. Participants who completed these two tasks received a $10 Amazon gift card.

Step 4: Representation – Data Analysis

Multidimensional Scaling: After the structuring of and rating of statements was complete, the quantitative analysis began with a goal of creating a visual map of the individual items. Analyses were conducted using the R programming language and Microsoft Excel. Data from Step 2 was organized into 100 x 100 similarity matrix for each student, which denoted whether a pair of statements had been grouped together. An overall similarity matrix was constructed by summing the matrices for all students. Multidimensional scaling (MDS) uncovered relationships between statements to produce a two-dimensional point map. A stress index was calculated to assess the fit of the solution to the data. Generally, a stress value between 0.10 and 0.35 indicates a good fit (Moreno, Kota, Schoohs, & Whitehill, 2013).

Hierarchical Clustering: A cluster map was created using hierarchical clustering of the MDS coordinates. Hierarchical clustering divided the point map into conceptual clusters based on similarity of ideas. Statistical analysis does not provide any specific mathematical solution for the optimal number of clusters, thus the authors determined the final number of clusters using a sequential process of generating versions of the concept map with a change of one cluster per version. The process involved reviewing cluster arrangements sequentially and identifying the optimal solution through the examination of cluster merging and conceptual understanding of the statement groupings. The lower and upper bound of the number of clusters considered was determined by the minimum and maximum number of clusters created by the students. In this case, the authors considered concept maps ranging from 5 clusters to 17 clusters. Each cluster was labeled based on (1) predominant cluster idea and (2) student produced labels. These labels were developed by and agreed upon by all authors. The final map was reviewed by 5 students from the Cohort #2 to establish qualitative consistency and internal validity.

Pattern Matches and Go-Zone Analysis: Overlaid on these steps the authors analyzed the ratings provided by the students in aggregate as well as by the demographic information that was captured in the survey (gender and academic level). An average rating for each statement was produced for each rating scale. Average cluster ratings generated from the cluster statement averages were used to produce pattern match comparisons between groupings of students and rating scales. Pattern matches provide a view of how global workforce perceptions vary across student contextual variables and the strength of the relationship between two sets of average ratings. Finally, to understand the relative ratings of statements, a go-zone analysis was conducted for each cluster. Go-zones are bivariate X-Y graphs of ratings, shown within quadrants constructed by dividing above or below the mean for both importance and confidence ratings. Statements in the lower-right quadrant (high importance but low confidence) represent the most actionable ideas within each cluster.

FINDINGS

The study results are separated into three areas of the concept mapping analyses: concept map development, pattern matching, and go-zone analysis.

Step 4: Representation – Results

Concept Map Development: The open source statistical package R was used to create a range of cluster solutions. After an iterative process involving the research team and students from Cohort #2, the final 7-cluster solution was chosen and the final point and cluster map are shown in Figure 1. Each number on the point map represents a brainstormed statement and how each individual statement conceptually relates to all the other statements generated. The relationship is indicated by the proximity of the numbers to each other (i.e. number placed closer together means those statements were often sorted together by the students and the farther away the numbers are from one another, the less often they were sorted together). A complete list of statements for each cluster is presented in Appendix A. A 7-cluster solution was chosen because it produced a richer description and understanding of the different dimensions of student global workforce perceptions. The stress value for the fit of the MDS solution was 0.204. Stress reflects the goodness-of-fit by measuring how accurately the concept map represents the way the students structured and organized the information (Stoyanov et al., 2013). The stress value obtained is consistent with the recommended range for concept mapping studies (Kane & Trochim, 2007; Rosas & Kane, 2012).

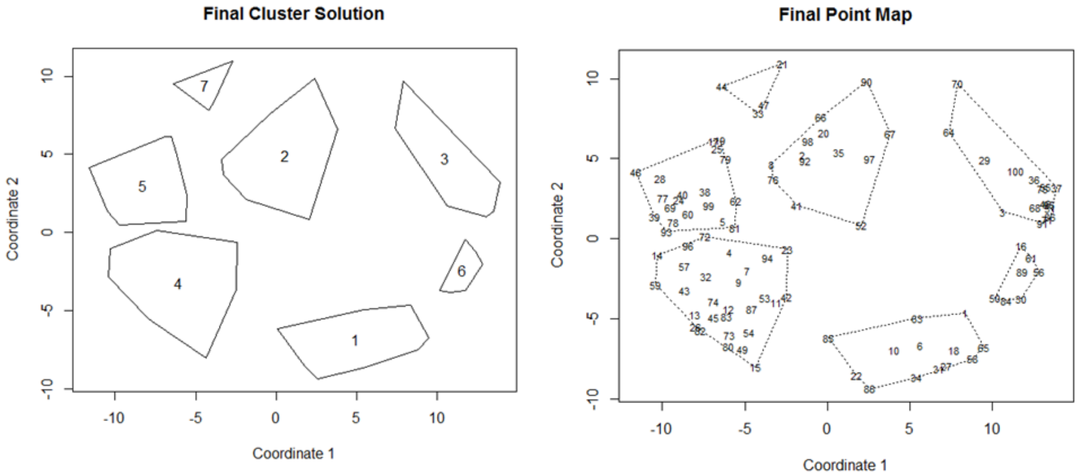

Figure 1. Final Cluster and Point Map Solutions

Cluster labels were generated based on the collective theme of the statements and from Cohort #2's proposed cluster labels. Table 3 shows the final cluster labels, a shortened title, and examples of the items generated by Cohort #1 contained within each cluster. Shortened titles were developed to simplify the labeling of figures in subsequent sections. Table 3 also shows the number of statements that fall into each cluster, respectively.

Pattern Matching: After the final cluster map was selected and analyzed, pattern matches were constructed. The results of the pattern matching analysis illustrate how different groups of students from Cohort #2 rated each of the clusters on importance and confidence. For pattern matches, the more evenly the lines are drawn across, the greater the level of agreement there is between two groups' cluster rating averages. Labels on the axis are the same labels as the clusters created and are in descending order of the average rating. A Pearson Correlation coefficient (r) is calculated for each pattern match to show the strength of the relationship between the ratings. A value of 0 indicates no correlation and no match, whereas a value of -1 or +1 indicates perfect correlation and a perfect match (Kane & Trochim, 2007). Five pattern matches were constructed:

1. Student Pattern Match – Importance vs Confidence (Figure 2)
2. Importance Pattern Match – Males vs Females (Figure 3)
3. Confidence Pattern Match – Males vs Females (Figure 4)
4. Importance Pattern Match – Lower Classmen vs Upper Classmen (Figure 5)
5. Confidence Pattern Match – Lower Classmen vs Upper Classmen (Figure 6)

The first pattern match (Figure 2) examines the difference between importance and confidence for all undergraduate engineering students in Cohort #2. Results demonstrate that undergraduate engineering students place less importance on 'globally related skills' than on more 'traditional engineering skills'. Moreover, students are generally more confident in attaining those traditional engineering skills compared to the globally related skills. The r = 0.785 indicates a high level of consistency between what students find important regarding global workforce preparation and their confidence in turn. What is unknown is whether the low importance of the globally related skills is due to a lack of confidence in attaining those skills or vice-versa.

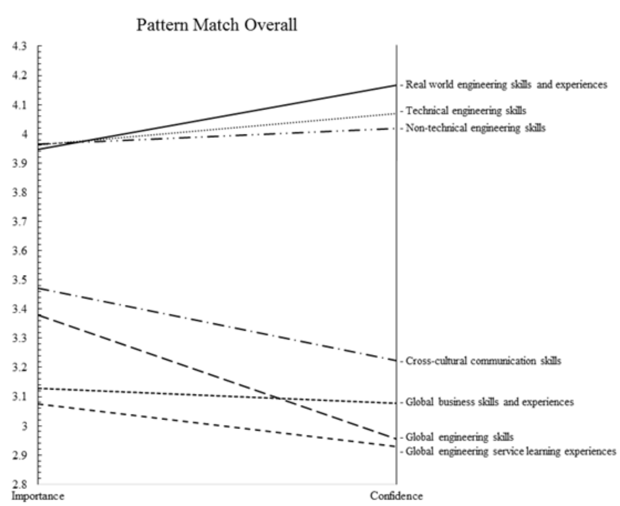

Figure 2. Student Pattern Match - Importance vs Confidence. Pearson's r = .785

Table 3. Student global workforce perception clusters and example items

Cluster # and label	Cluster description	Example items within cluster	# of items in the cluster
(1) Non-technical engineering skills	Personal and professional engineering knowledge, skills, and attitudes. Ideas in this cluster reflect a transferrable/universal skill set including the ability to work with others, communicate effectively, and adapt to unfamiliar situations.	How to work effectively in teams; Develop an open mind	13
(2) Global engineering skills	The knowledge, skills, and understanding required for global engineering work. Ideas in this cluster reflect an engineering global competency skills set including knowledge of global environments and how to effectively solve engineering problems with a global perspective.	How engineering processes compare based on different economic levels; How to get work done efficiently in a global engineering project	13
(3) Technical engineering skills	General/technical engineering skills required to be a successful engineer. Ideas in this cluster reflects a more fundamental engineering skill set including knowledge of math and science, design principles, and basic engineering practice.	Have a good understanding of the basic principles of engineering; Know basic engineering practices that are applicable in any context	16
(4) Cross-cultural communication skills	Global communication and teamwork skills required for working with people from other cultures. Ideas in this cluster reflect a personal and professional global engineering skill set including knowledge of the differences in cultural work ethics, managing cultural change, and how to bridge cultural gaps through communication and teamwork. Proficiency in a foreign language is also an element of this cluster.	Communicate with global professionals despite language or cultural barriers; How to translate my ideas to international groups clearly	28
(5) Global business skills and experiences	Global business knowledge, skills, and understanding gained through personal experiences in other cultures. Ideas in this cluster reflect the learning/skill/personal traits about working with other cultures, gained through experiences abroad, including understanding cultural differences, having a broader perspective, and how people differ in other parts of the world.	Have a broader perspective on the world through personal experiences; Gain work experience abroad	19
(6) Real world engineering skills and experiences	Engineering skills expected by employers by relating the knowledge gained in the classroom to real world problems. Ideas in this cluster also reflect students' efficacy in utilizing skills in industry.	How to fully use and implement skills I learned in college; Know what is expected by employers	7
(7) Global engineering service learning experiences	Multinational, humanitarian global engineering experiences. Ideas in this cluster reflect the knowledge and skills needed to make the world a better place via global engineering work.	The general environmental issues that other countries are facing and their efforts to combat them; Help developing countries	4

The impact of contextual factors such as gender and academic level can be visually represented using the pattern match diagrams. The second pattern match (Figure 3) compares average importance ratings between male and female undergraduate engineering students from Cohort #2. These results show that females consistently place more importance on globally related skills when compared to their male counterparts. Meanwhile, males place a slightly more importance on the traditional engineering skills than females, resulting in a much larger gap for what males find important regarding global workforce preparation. In other words, the relative importance that females place on the skills and experiences required to be successful in the global workforce are much more congruent than males, who place the emphasis on the traditional engineering skills. The r = 0.771 indicates a high level of consistency between what males and females find important, with the main difference being the magnitude of said importance.

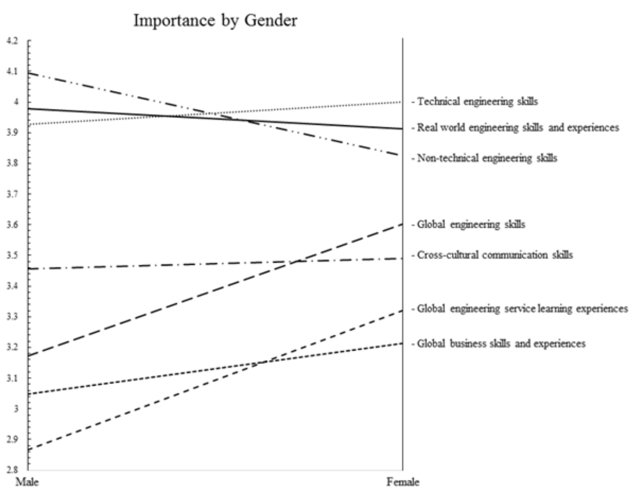

Figure 3. Importance Pattern Match - Males vs Females. Pearson Correlation r=.771

The third pattern match (Figure 4) compares average confidence ratings between male and female undergraduate engineering students from Cohort #2. The results indicate that both males and females are far less confident in attaining the globally related skills and experiences than the traditional engineering skills and experiences. Females are less confident than males in acquiring skills and experiences regarding global workforce preparation across all clusters, even though females place more importance on these globally related skills. The r = 0.836 indicates an extremely high level of consistency between males and female confidence ratings, meaning relative confidence amongst the clusters doesn't depend on gender. Only the magnitude of confidence levels differs between males and females.

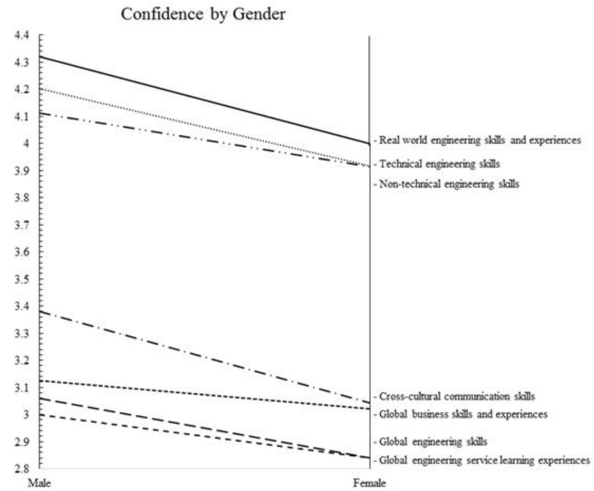

Figure 4. Confidence Pattern Match - Males vs Females. Pearson Correlation r = .836

Finally we compared the importance and confidence by academic level. We grouped freshman and sophomores as "lower classmen" and juniors and seniors as "upper classman" for purposes of this analysis. The fourth pattern match (Figure 5) compares average importance ratings between lower classmen and upper classmen undergraduate engineering students from Cohort #2. The results of this pattern match indicate the traditional engineering skills are valued more highly than globally related skills, regardless of academic standing. The traditional engineering skills are valued highly by both lower and upper classman. However, when it comes to the value placed on the globally related skills the results are inconsistent. Global engineering skills and global engineering service learning/experiences are valued more highly by upper classmen and cross-cultural communication and global business skills/experiences are valued more by lower classman. The r = 0.640 indicates an only a moderate level of consistency between lower classmen and upper classmen importance ratings. There isn't broad agreement on the importance of the skills and experiences needed to be successful in a global work environment based on academic level, suggesting that as a student progresses through college, their views on the importance of globally related skills remains unchanged or even wains in certain areas. This could be due to a lack of reinforcement of these skills and experiences in engineering curricula.

The fifth (and final) pattern match (Figure 6) compares average confidence ratings between lower classmen and upper classmen undergraduate engineering students from Cohort #2. The results indicate that as students progress through college, their confidence in attaining the traditional engineering skills increases (with the exception of non-technical engineering skills). Meanwhile, students don't consistently become more confident in their confidence to attain the globally related skills. Both cross-cultural communication skills and global engineering skills have consistent confidence ratings for both lower and upper classmen. Global business skills and experiences and global engineering service learning experiences both increase, probably as a result of more opportunities and exposure to such experiences. The r = 0.885 indicates an only an extremely high level of consistency between lower classmen and upper classmen confidence ratings.

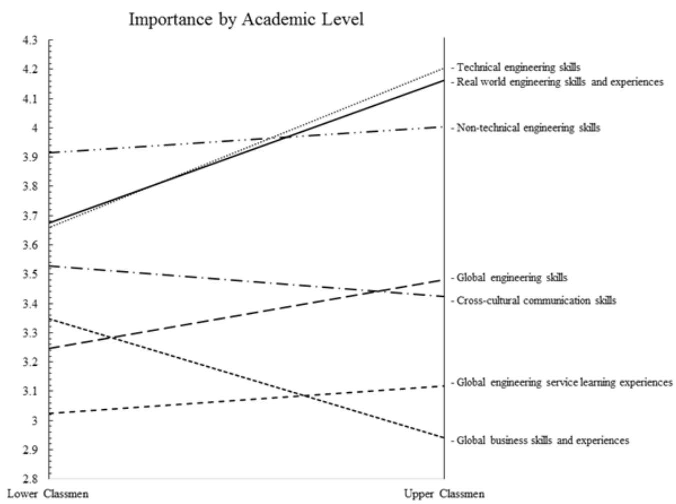

Figure 5. Importance Pattern Match - Academic Level. Pearson r = .640

This suggests that, in general, the confidence an engineering student has in attaining the skills (traditional and global) required to be successful in the global work environment doesn't change dramatically throughout college, and in certain areas, confidence actually decreases (Non-technical engineering skills and Global engineering skills).

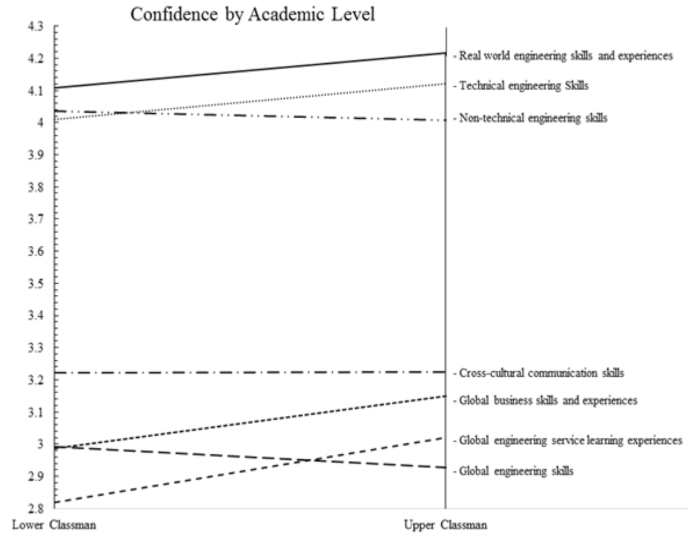

Figure 6. Confidence Pattern Match - Academic Level. Pearson r = .885

Go-Zone Analysis: In addition to the pattern matching analysis, go-zone analyses were conducted on each cluster. Go-zone analysis are bivariate X-Y graphs that show the average ratings for two variables on each statement within a specific cluster shown within quadrants constructed by dividing above or below the mean of each variable. These plots provide greater within-cluster detail than pattern matches. Table 4 shows which statements in each cluster have higher than average importance with lower than average confidence. A priority index (PI), which show those statements that need the greatest attention (higher positive scores), are also calculated for each statement. This analysis provide actionable information as to what program administrators and curricula developer should focus on what preparing students to be successful to enter the global workforce.

Table 4. Go-Zone Statements[a]

	Importance	Confidence	PI[b]
Cluster 1: Non-technical engineering skills	**3.97**	**4.02**	**0.078**
22. How to communicate effectively to unfamiliar audiences	4.12	3.92	0.049
65. Be able to adapt and come up with solutions to problems in work environments and situations	4.13	3.83	0.073
88. Work effectively with all groups of people	4.46	3.96	0.112
Cluster 2: Global engineering skills	**3.38**	**2.95**	**0.207**
8. International problem solving	3.44	2.76	0.198
52. Exposure to working on problems from a global perspective	3.68	2.92	0.207
97. How to get work done efficiently in a global engineering project	3.56	2.79	0.216
Cluster 3: Technical engineering skills	**3.96**	**4.07**	**0.107**
91. Know how to create everything safely	4.21	3.76	0.107
Cluster 4: Cross-cultural communication skills	**3.47**	**3.22**	**0.175**
13. Better communication with engineers in other countries	3.72	3.08	0.172
54. Communicate with global professionals despite language or cultural barriers	3.58	2.96	0.173
83. How to professionally interact with people of other cultures	3.88	3.21	0.172
87. How to translate my ideas to international groups clearly	3.92	3.21	0.181
Cluster 5: Global business skills and experiences	**3.13**	**3.08**	**0.1265**
5. How people differ in different parts of the globe	3.54	3.00	0.153
38. Understand the viewpoints and reasoning behind the values of other countries	3.33	2.96	0.111
62. How our cultural ethics are different from other people	3.42	2.96	0.135
79. Understand the ways other cultures think about common problems	3.36	3.00	0.107

a. Clusters 6 and 7 did not have any statements that fell both above average importance and below average confidence.
b. Priority Index (PI) = (1-confidence level/importance level). Higher magnitude indicates higher priority.

All of the statements included in the go-zones should be addressed when preparing engineers to be successful in the global work environment. However, Table 4 suggests the highest priority areas (in rank order) include more exposure and practice of:

1. International problem solving via global engineering projects
2. Communicating and working effectively across cultures
3. Understanding the differences in values, ethics, and problem solving strategies of other cultures

The priority area labels above were determined based on the clusters with the highest overall priority indices and the thematic similarities of the statements therein. While many engineering curricula might already include elements of these three areas, the results of the go-zone analysis show that there is a mismatch between the importance of these skills, and the confidence students have in attaining them.

INTREPRETATION AND UTILIZATION

This study used concept mapping to visually organize the perspectives of 126 undergraduate engineering students who were given the prompt: “What do you hope/expect to know upon completion of college to better prepare you to work successfully in a global engineering environment?”. Concept mapping revealed that students expect to attain a mix of traditional engineering skills and experiences (clusters 1, 3, and 6) and global engineering skills and experiences (clusters 2, 4, 5, and 7). These findings highlight that students have some awareness of the importance of skills outside of their technical coursework. When the clusters were finalized, 4 students from Cohort #2 validated the research team’s cluster solution and commented on their observations. The resultant concept map clusters address many elements of industry and academically-based frameworks for global competency in engineering, which suggest the necessary competencies for a global engineering consist of a mix of traditional, disciplinary knowledge, along with cross-cultural teamwork, communication, and world knowledge (Ball et al., 2012; Levonisova et al., 2014).

Pattern matching using ratings of confidence and importance revealed that students place high importance on many items that were categorized as global engineering skills while rating themselves as less confident that they will attain these skills by graduation. Similar results were found in a study conducted by Jesiek et al. (2010) suggesting that a gap exists between student perceptions of desired global competencies compared to their levels of confidence and ability in many of those same areas (Jesiek, Sangam, Thompson, Chang, & Evangelou, 2010). Analyzing these pattern matches by contextual factors exposed additional interesting findings. The analysis by gender showed that males and females are far less confident in attaining the globally related skills and experiences than the traditional engineering skills and experiences. Females are less confident than males in acquiring skills and experiences regarding global workforce preparation across all clusters, even though females place more importance on these globally related skills and, overall, participate in more globally-based experiences than their male counterparts. This academic confidence gap between male and female students has been reported in many other engineering and non-engineering related contexts (Bong, 1999; Burger, Raelin, Reisberl, Baile, & Whitman, 2010; Felder, Felder, Mauney, Hamrin, & Dietz, 1995; Pajares, 2002). Yet, this study suggests that this confidence gap might also exist in a global engineering context. A greater effort could be made in and outside the classroom to provide our students with opportunities to develop these skills. A student who validated the final solution commented that faculty should encourage students in their classes to gain hands-on experiences that will develop these skills.

It is troubling to note that, unlike the technical engineering skills, our data did not show a consistent increase in confidence in attaining the global engineering skills from underclassman to upperclassman. Perhaps this is due to the fact that many engineering students desired to study abroad but few at our institution do. As graduation approaches, students may be more aware of the opportunities they will not take part in before their careers begin. One of the students offered the following suggestion: “I think that incorporating some sort of challenge final project in higher level courses that force students to design something, etc. that must be presented to an international team with ease would be the ultimate test/ experience for students. For example, the project or paper would attempt to solve a problem that either a) international companies have or b) third world/ developing countries have to better develop their infrastructures, etc. Then, the presentation, solution and translation of ideas would be the rest, or the international problem solving/ adapting to unfamiliar and culturally different audiences.”

Reflecting on these results as a whole, these findings raise concerns that as institutions of higher education we may not be providing enough development of these skills within traditional coursework. While globalization and professional skills are taught in a variety of general education requirements in the engineering curriculum, the integration of these skills inside an engineering context (i.e., in a technical engineering course) would reinforce these learnings in their domain. Students have perspectives on what skills they perceive to be important to be successful but they may not have opportunities to assess their current skills against these criteria. As suggested by a student participant, the concept map could be used as a guide for students who will be joining the workforce. The concept map could also be used by faculty who want to emphasize global skill development in their courses.

CONCLUSION

This study is an exploratory application of the concept mapping methodology to better understand the dimensions related to student global workforce perceptions. The results from this concept mapping study showed that students have a variety of perspectives on the skills required to be successful in a global engineering environment. The concept map helped to organize these perspectives into 7 distinct categories. Within these categories students rated each statement by their perceived importance and their confidence to acquire these skills by the time they finish their undergraduate engineering degrees. The pattern matching analysis yielded insights on how various factors can influence perceived importance of these skills as well as the confidence to acquire them. A go-zone analysis revealed what areas of global workforce preparation engineering educators should focus on more (from the students' viewpoint). We acknowledge that the emphasis placed on technical problem-solving and disciplinary knowledge throughout the undergraduate curriculum influences the perspectives of our undergraduate students. It would be of interest to expand this research to include students from an institution with a formal international program or where a higher percentage of engineering students take part in global experiences.

This study supports a larger research effort that addresses the global workforce expectation differences between industry and engineering graduates. Future work therefore includes investigating what industry expects of entering engineering graduates. Work by the authors, as well as many other scholars, have looked in industry expectations for globally competent engineers (Ball et al., 2012; Lang, Cruse, McVey, & McMasters, 1999; Parkinson, 2009; Passow, 2012; Rajala, 2012; Streiner, 2015; Warnick, 2010). Future work proposed by the authors extends this work by relating global competence and success with educational preparation. Specifically, the question *"What do you wish you would have known upon completion of college to better prepare you to work successfully in a global engineering environment?"* will be answered and those findings will be triangulated with the findings from this study.

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APPENDIX

Appendix A – Statements by Cluster

Cluster 1: Personal and Professional Engineering Skills (Non-Technical)
See the importance of setting standards
Develop an open mind
Learn to be a more well-rounded person
How to appreciate the work
How to communicate effectively to unfamiliar audiences
Knowing how to adapt to unexpected situations
How to work effectively in teams
How to communicate effectively
Leadership skills
Develop a better understanding of different styles of work
Be able to adapt and come up with solutions to problems in work environments and situations
Tolerance
Work effectively with all groups of people
Cluster 2: The Knowledge, Skills, and Understanding Required for Global Engineering Work
Knowledge of the global environment
International problem solving
Knowledge of current engineering problems/topics in foreign countries
Know more about how things are done in engineering around the world
A global understanding and perspective brought about by my own experiences and coursework
Exposure to working on problems from a global perspective
The ability to think of worldwide engineering as a single endeavor
How engineering processes compare based on different economic levels
How to effectively do international engineering work
An understanding of what the world needs out of engineers
How engineering is applied across the world
How to get work done efficiently in a global engineering project
Better knowledge of the global market and how it can be affected by engineering faults or successes
Cluster 3: Technical Engineering Skills
Get hands on experience on engineering works
Technical skills necessary to start a career in a global engineering environment
Know basic engineering practices that are applicable in any context
Learn everything I need to know to be a competent engineer
The fundamental tools and areas of a knowledge expected of engineers
Have a better understanding of engineering fundamentals
Have a solid engineering education
How to make processes more green and apply them in the workforce
Standard engineering procedures
How my degree can be used to help people in need of basic necessities
Have a good understanding of the basic principles of engineering

Knowledge of different engineering designs
Be able to do engineering work successfully
Know how to create everything safely
Develop the technical engineering skills to qualify for an engineering position
The universal language of math and science
Cluster 4: Cross-Cultural Communication Skills
Know how different cultures influence the work style and product of employees
Be able to manage cultural change more easily
How to relate to co-workers from other countries
How to exchange ideas with people of all origins for global benefits
How to better interact with different people from various cultures
Better communication with engineers in other countries
How our work ethics are different from other peoples
How to work successfully in groups with differing backgrounds
Have the skills to learn quickly about other cultures
Work with people from difference countries by overcoming language barriers
Patience with the initial cultural shock
International networking
Combine foreign language fluency with the proficiency I will gain in engineering
How to communicate clearly and concisely in a cross-cultural environment
How to work with diverse groups of different backgrounds
A basic description of the challenges of global communication
Communicate with global professionals despite language or cultural barriers
Be able to obtain a job abroad
Proficiency in a foreign language
Experience interacting with different cultures
How to react to a foreign coworkers
How to work with coworkers in other countries
How to interact with people of different backgrounds
How to overcome a language barrier
How to professionally interact with people of other cultures
How to translate my ideas to international groups clearly
Have the skills to work internationally
How to bridge cultural gaps
Cluster 5: Global Business Knowledge, Skills, and Understanding Gained Through Personal Experiences in Other Cultures.
How people differ in different parts of the globe
Understand international business policies
Know the business culture of other countries
Broaden my knowledge to include more cultures around the globe
Understand how business is done in other cultures
Study abroad
Understand the viewpoints and the reasoning behind the values of other countries
Visit another country and experienced a different lifestyle
Learn about other cultures first hand

Gain work experience abroad
Learn about the different values that other countries emphasize
How our cultural ethics are different from other people
Understand cultural differences
A foreign experience
Study habits and behaviors of international students
Understand the ways other cultures think about common problems
Have a broader perspective on the world through personal experiences
Meet different people and understand their culture
Develop a better understanding of different cultures
Cluster 6: Engineering Skills Expected by Employers, Applied in Real World Contexts.
Experience in the job field will allow you to learn the material specific for your position
Problem solving skills
Know what is expected by employers
An engineering mindset that will help me to look at and solve problems
Formulate optimal solutions
The ability to assess a specific environment or situation
How to fully use and implement skills I learned in college
Cluster 7: Global Engineering Service Experiences and Learning
The general environmental issues that other countries are facing and their efforts to combat them.
How a global engineering project is coordinated among locations
Help developing countries
Knowing how other countries run their plants in ways that are safe and efficient