Cultural Dimensions in Academic Disciplines, a Comparison Between Ecuador and the United States of America

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Abstract

Broadening participation in engineering has been part of the engineering education research agenda for years. We argue that if we can understand the traits of the different dimensions of culture in engineering, we can identify potential solutions to broaden participation. In this study, we are comparing how engineering students from Ecuador and the United States characterize their culture orientation based on Hofstede´s cultural dimensions theory. Data were collected with engineering students at major polytechnic universities in Ecuador and the United States. The survey was translated into Spanish for the Ecuadorian data and was reviewed by several native Spanish speakers. Results provide preliminary information on how students perceive aspects of culture like uncertainty avoidance, individualism, power distance, and masculinity. We discuss the relationship of these constructs with aspects of the engineering program. Implications for research and practice are provided.

Introduction

As engineering continues to be more globalized, it is essential to explore how different national cultures impact the field in the quest for global competency and intercultural engineering. The engineering field continues to advocate for preparing engineers for global practice, capable of functioning in transnational cultures other than their own. However, engineering disciplinary knowledge and practice are often influenced by national history and culture [1]. Culture accounts for the meaning that people attach to their world and its experience [2], including the values and norms that dictate their behavior and interactions [3]. Hence, in an academic setting, culture defines the interactions among the different stakeholders, including the interaction between students and teachers, which is a significant component of the learning process. While cultural dimensions have been used to study cultural behavior in diverse fields to improve learning [4], there is a limited understanding in the literature about what role cultural differences play in engineering differences. Mahadevan [5] contends that engineering education needs to transgress from national culture difference to understanding the multiple realities of engineering and “acknowledge cultural complexity in engineering through an integrated development of competencies for utilizing cultural diversity benefits” ([5], p.658), in the drive for intercultural competencies. Hence, understanding the engineering discipline’s cultural traits in other countries allows us to identify cultural aspects shared by students providing information to improve disciplinary practice in engineering education and promoting global and intercultural engineering.

Therefore, this initial paper, as part of a multi-country project, focuses on understanding how students from two major universities in the United States (U.S.) and Ecuador, characterize their cultural orientations to provide a better perspective on how to create classrooms that consider those cultural similarities and differences to positively impact students’ learning and development [6]. The engineering culture in the U.S. is “often characterized as masculine, individualistic, and function-oriented” ([7], p.1). In contrast, in Ecuador, very little research focuses on understanding the engineering discipline’s cultural traits despite the vital link between engineering and economic development and the growth of engineering programs in this country [8]. To better understand engineering's disciplinary practice in these contexts, we sought to measure cultural traits among engineering students in the U. S. and Ecuador based on Hofstede's cultural dimensions to explain each context and compare the two countries' results. More specifically, the study answers the following question:

1. How do personal cultural orientation of engineering students compare to Hofstede's dimensions of National Culture between the U.S. and Ecuador?

Theoretical framework

Hofstede's theory of dimensions of national cultures was developed in the mid-1960s [9]. He describes culture as patterns of thinking, feeling, and acting that every human being carries [3], [10] and a "system of shared meanings that may be unique to a particular society or a group of societies" ([11], p.4).

Hofstede's [9] original analysis yielded four dimensions of culture based on the problems that were inherent to all societies: (a) social inequality, including the relationship with authority, (b) the relationship between the individual and the group, (c) ways of dealing with uncertainty and ambiguity, which turned out to be related to the control of aggression and the expression of emotions, and (d) concepts of masculinity and femininity: the social and emotional implications of having been born as a boy or a girl. Based on these issues, Hofstede [9] labeled his dimensions of culture as ***power distance*** (from small to large), ***individualism*** (versus collectivism), ***uncertainty avoidance*** (from weak to strong), and ***masculinity*** (versus femininity). Despite later developing more dimensions, for the purpose of this study we are focusing on the original ones:

- *Power Distance* addresses the extent to which the "less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally" ([10], p.61). Notably, this dimension addresses inequity as defined and endorsed from below (i.e., the followers rather than the leaders) [12], [13].
- *Uncertainty Avoidance* addresses the degree to which members of a culture can operate comfortably with uncertainty. According to Hofstede et al. [10] in cultures with high uncertainty avoidance, unstructured situations (novel, unknown, surprising, etc.) are perceived as intimidating; these cultures seek to minimize such situations via both legal controls (e.g., laws, rules, security measures) and religious philosophies that rest on absolute truth. Cultures that accept uncertainty, in contrast, tolerate diverse opinions, have fewer rules, and adopt more relativist philosophies.
- *Individualism/Collectivism* addresses the relationship between individuals and the larger group. In an individualistic culture, individuals are loosely connected; everyone is expected to operate independently and people do not strongly identify with a group norm [11], [12]. In collectivist cultures, people are tightly connected and consolidated into cohesive in-groups with strong emphasis on group norms and unity [11].
- *Masculinity/Femininity* refers to the continuum representing how emotional roles are distributed across genders, with assertive roles aligned with the masculine pole of the continuum and caring roles aligned with the feminine pole. Hofstede considered women to show less variation by culture than men; i.e., men were considered more assertive and competitive in masculine cultures, while women exhibit similar levels of caring in both

masculine and feminine cultures. Masculine cultures thus experience a greater gap between men's and women's roles [9], [10], [12]

Despite Hofstede's theory receiving some criticism (see [14] for full details), we consider there is value in testing Hofstede's theory of dimensions of national culture in academic settings. Hofstede's model uses dimensions of culture that have been validated in a variety of contexts and scenarios [14], [15], and we have been using his theory to explore different engineering disciplines [6]–[8], [8], [14].

Cultural context: Ecuador vs. the United States

To understand the context for our study, we used Hofstede's online tool [16] to understand cultural differences between the U.S. and Ecuador, based on Hofstede's dimensions. Figure 1 presents how the countries score in the four main dimensions.

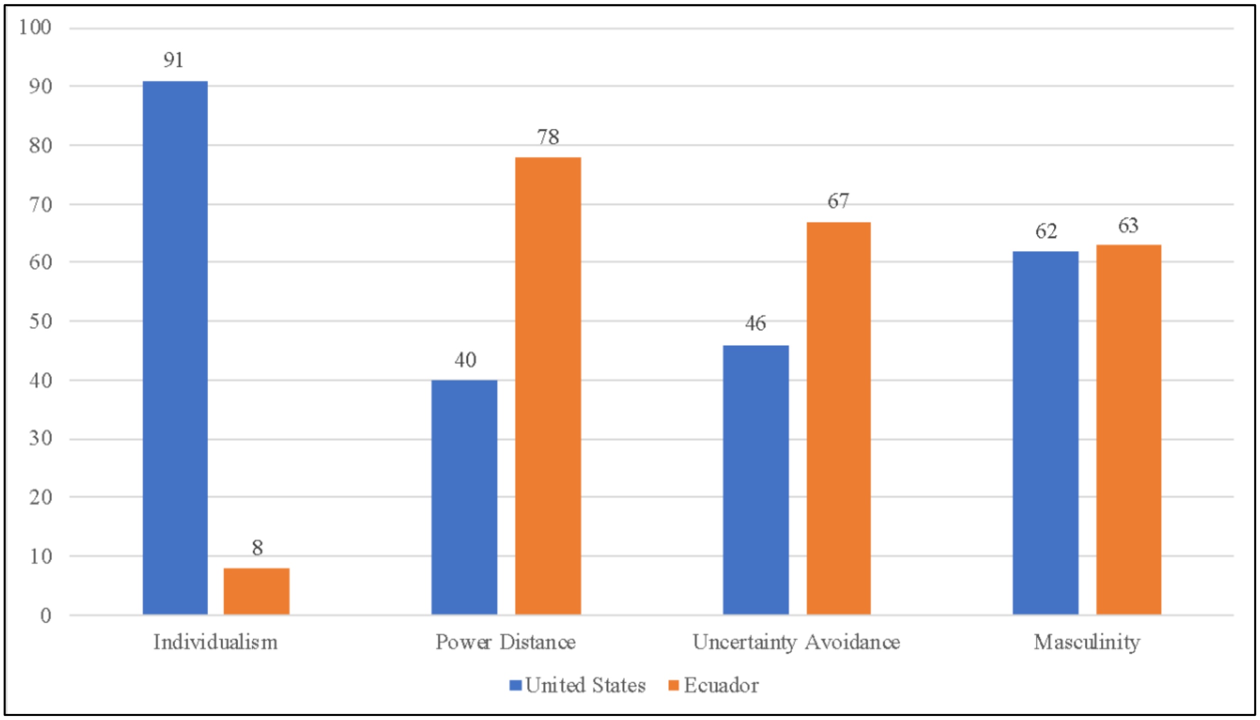

Figure 1. Country comparison between Ecuador and the United States according to Hofstede [16]

Ecuador has one of the lower scores in Individualism, considered to be amongst the most collectivistic cultures in the world. This means that Ecuadorians' belonging to groups is important [16]. It also means that when compared to their score in power distance, conflict will be avoided to maintain group harmony. In Ecuador, relationships are prioritized over tasks, and cooperative efforts and teamwork become very effective to achieve goals. This is represented in demonstrations of solidarity towards members of the groups but also implies that outsiders can perceive barriers to have access or feel excluded. In contrast, the U.S. has a very individualistic culture with an expectation that people will look after themselves and their immediate families only [16].

In the U.S., nevertheless, there is a recognition of the importance of understanding how to operate in groups; however, this is usually limited to business relationships mostly, and people are considerably less inclined to develop deep friendships with people outside their circle.

In terms of Power Distance, Ecuador scores considerably higher than the U.S. Power distance defines the extent to which power differentials in society are accepted. Ecuador as a society believes that inequalities amongst people are part of life and, therefore, acceptable. Hence, authoritarian powers like the military play an important role in political life [16]. Inequality is usually connected to social class and is widely accepted in all aspects of Ecuadorian society. The U.S., on the other hand, has a lower score of Power Distance. This emphasizes the premise of justice for all, which is so prevalent in the culture [16]. The U.S. society emphasizes equal rights, and hierarchy is established for convenience. Teams are valued by their expertise rather than by the possible relationships that can be formed, and authority is less prevalent than superiors' and employees' productive interactions.

Uncertainty Avoidance is a dimension that presents similar differences to power distance. Ecuador's high score of 67 indicates the society tends to avoid ambiguity. This represents some acceptance of the fact that the future is not fully known or anticipated. Ecuadorians will have several mechanisms to avoid ambiguity, emotions are openly expressed, legislation is extensive and detailed, and religion and superstition are highly valued [8], [16]. When connecting to the collectivistic dimension, this also means that traditions of each group are very respected by their members. The U.S. score is below average, represented by a degree of acceptance of new ideas and trying new things. This can also be reflected in the good perception that innovation and creating new products have [16].

Finally, in terms of masculinity, the dimension that explains how much a society is driven by competition, achievement, and success, Ecuador and the U.S. have very similar rankings in the middle of the spectrum. The countries can be considered highly success-oriented and driven societies, competitive, and status-oriented [16]. While these two countries rank similarly, the competitive drive differs according to their cultural dimension of Individualism. For example, Ecuador is a highly collectivistic country, so competition is directed towards other groups or social classes rather than one's in-group; in the United States, on the other hand, competition is driven at the individual level [16].

Institutional context

Virginia Tech is a public land-grant research university and offers 280 undergraduate and graduate degree programs to some 34,400 students and manages a research portfolio of more than $500 million. The College of Engineering, is one of largest producers of engineering graduates in the nation and has been conducting life-changing research. The college's rigorous curriculum, hands-on learning, and industry engagement produce graduates who are poised for success -ready to work, innovate, and lead. The college offers 14 undergraduate degree-granting engineering majors, 16 doctoral, and 19 master's programs in 18 areas of study and is comprised of approximately 384 tenured and tenured track faculty across 12 departments and two schools. The college continues to be at the forefront of innovation and research, working in disruptive technology areas that include: autonomous systems and robotics, cybersecurity, cyber-physical systems, the internet of things, data analytics and decision sciences, injury and occupational biomechanics, manufacturing materials, and systems, energy engineering and science, sustainable infrastructure and construction, transportation and logistics, turbomachinery and diagnostics, corrosion and water, and wireless communications and security.

Universidad San Francisco de Quito (USFQ), is a private university located in Quito Ecuador, founded as the first Liberal Arts school in Latin America in 1988, but it was not until 1995 that obtained official recognition by the government of Ecuador. Being the only Liberal Arts school in the country up to date, *USFQ* stands on four core values which are *goodness, truth, beauty, and individual freedom* [17]. Although the tuition and collegiate fees are the highest in the country, about half of the students receive a form of financial aid directly from the university. *USFQ* has about seven thousand undergraduate students, and a little under one thousand graduate students, with a student-faculty ratio of 11 [17]. *USFQ* is ranked #1 in Ecuador and #55 in Latin America [17]. Promoting minorities and diversity is a well-known characteristic, which can be seen by the strong program that supports a population of about one hundred indigenous students to enroll in the university [18]. Furthermore, *USFQ* yearly hosts about one thousand students from all the continents of the world to study abroad for a semester, a summer, or the full academic year. Being in the most biodiverse country of the world, *USFQ* has developed partnerships with international higher education institutions and the Ecuadorian government to build and manage two world-class research campuses in the Galapagos Islands with the University of North Carolina, and in the Amazon Jungle Tiputini with Boston University. Local and international students, as well as the world academic community, can do research or academic activities in both centers [19].

Methods

In order to better understand the differences between personal cultural orientation in engineering students from the U.S. and Ecuador, data were collected quantitatively using a survey adapted by Sharma [4] to measure Hofstede's cultural dimensions within engineering students. This survey was not only validated by Sharma [4] but also the authors validated it for its use in academic disciplines [15].

Sharma's survey [4] reconceptualizes five cultural factors--Power Distance, Individualism, Masculinity, Uncertainty Avoidance, and Long-Term Orientation as ten personal cultural orientations (PCO) and uses a 40-item scale to measure them. Sharma believed that Hofstede's national-level constructs "may not fully represent the diversity in the cultural orientations of the citizens of a country since they may not possess the same level of their national cultural characteristics" ([4], p.788); in other words, Hofstede's original scale presented challenges when measuring culture at an individual level. For our purposes, we focus on the first four, original cultural factors and adapt Sharma's survey based on these factors alone. Below is a description of the four original factors reconceptualized as personal cultural orientations according to Sharma:

- Individualism-Collectivism as Independence and Interdependence, two negatively correlated dimensions, in which Independence is associated with individualism and Interdependence is related to conformity

- Power Distance as Power and Social Inequality, two positively correlated dimensions, in which Power is associated with relationships between people and authority and Social Inequality is related to hierarchy versus egalitarianism
- Uncertainty Avoidance as Risk Aversion and Ambiguity Intolerance, two positively correlated dimensions, in which Risk Aversion represents reluctance to taking risks and Ambiguity Intolerance represents the extent of tolerance toward uncertain situations
- Masculinity-Femininity as Masculinity and Gender Equality, two independent dimensions, in which Masculinity represents assertiveness, self-confidence, aggression, and ambition, and Gender Equality represents the perception of men and women as equal in relation to social roles, capabilities, rights, and responsibilities.

Data collection

The survey was administered electronically using the online survey platform Qualtrics. It was distributed in both participating institutions in the U.S. and Ecuador. Data were collected from two samples, one of 224 US engineering students and another of 152 Ecuadorian engineering students registered in different engineering programs from two universities, USFQ in Ecuador and Virginia Tech in the United States. The survey was translated into Spanish and piloted with experts. Only data from students in similar programs from both universities were taken into account for the study. The engineering programs were: Mechanical, Electrical, Civil and Environmental, Industrial and Systems, Chemical, and Computer engineering. Students surveyed were in different semesters in their programs.

Data analysis

Data were processed and managed through Qualtrics and cleaned in Excel. The results obtained from the participants were analyzed using SPSS V.22 software. Descriptive statistics are presented and demographics included gender, program, race, GPA, and semester in the program were obtained for both samples. In order to determine differences in the four cultural dimensions between programs and universities, t-test, ANOVA of one factor were run comparing each dimension.

Research quality and limitations

There are several limitations of this study. First, data represent only two universities in both countries, hence, we need to be careful with the generalization of these findings. Similarly, we are not accounting for cultural differences based on the locations of the institutions in both countries. However, we took several steps to assess the quality of the research. First, the study stands on previous studies conducted by some of the authors [8], [14]. Second, content validity was discussed and determined by the researchers in consensus. Third, construct validity is addressed by using a survey that has been proven to be an effective tool to assess the cultural dimensions of a group [6] for review and the authors even demonstrated its validity in academic settings [15].

Results

Table 1 shows the composition of the two samples by gender and race. Most of the students in both samples were male (69%). The White race (78.1%) is predominant among the U.S. students' sample, while the Mestizo race (91.1%) is predominant in the Ecuadorian sample.

Table 1. Composition of samples by gender and race

Characteristics		**U.S.**		**Ecuador**		**Total**	
		n	**%**	**n**	**%**	**n**	**%**
Gender	Female	63	34.8	39	26.4	102	31.0
	Male	118	65.2	109	73.6	227	69.0
	Total	**181**	**100**	**148**	**100**	**329**	**100**
Race	Hispanic	8	4.5	1	0.7	9	2.8
	American Indian or Alaskan	3	1.7	-	-	3	0.9
	White	139	78.1	6	4.1	145	44.8
	Asian	25	14.0	-	-	25	7.7
	Black or African American	3	1.7	1	0.7	4	1.2
	Mestizo	-	-	133	91.1	133	41.0
	Indígena o Nativo de la Sierra	-	-	5	3.4	5	1.5
	Total	**178**	**100**	**146**	**100**	**324**	**100**

Note: Missing values were not computed within the samples

The distribution of the samples by engineering programs is shown in Figure 2. Most of the participants from the U.S. University were in Mechanical, Electrical and Industrial and Systems Engineering programs, and in the Ecuadorian University were in Mechanical, Civil and Environmental, and Industrial and Systems engineering programs.

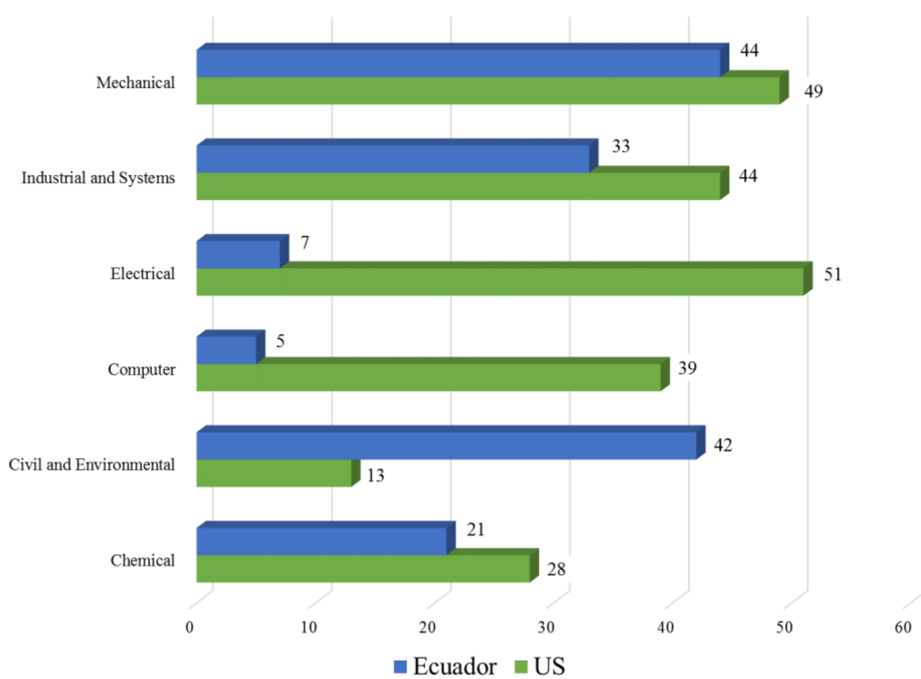

Figure 2. Participants by engineering programs in each university

We consider that demographics and major distribution between data sets from both countries are similar enough to make some comparisons. In Table 2 we describe the mean and standard deviations by country considering all engineering data. We consider these descriptive statistics important to get a sense of the major differences between countries. For example, most of the four dimensions being evaluated present very similar results. Hence, we need to conduct further analysis to determine if there are any statistically significant differences to consider.

To determine the statistically significant differences among the results a t-test was run for the four dimensions between the two samples from the two universities. Table 2 shows the means and standard deviations and table 3 results from the t-test.

Table 2. Means and standard deviations of each dimension by university

Dimension	University	n	$\underline{x}$	σ
Individualism - Collectivism	US	224	5.7338	0,79628
	Ecuador	147	6.0612	0.52207
Power Distance	US	204	3.4087	0.94075
	Ecuador	148	3.6191	0.89895
Uncertainty Avoidance	US	197	4.2944	1.07050
	Ecuador	147	4.1029	1.08635
Masculinity - Femininity	US	195	5.1686	0.59775
	Ecuador	146	5.4144	0.63649

Table 3. T-test difference of means in each dimension between universities

Dimension	t	gl	sig.
Individualism - Collectivism	-4.734	369.00	0.000*
Power Distance	-2.110	350.00	0.036
Uncertainty Avoidance	1.631	342.00	0.104
Masculinity - Femininity	-3.654	301.47	0.000*

(*)Significance at $\alpha/2 = 0.025$

The t-test to compare means between students indicates a significant difference in the Individualism vs Collectivism (p=0.000) and Masculinity vs Femininity (p=0.000) dimensions. Hence, to better understand these two constructs we continued conducting more inferential statistics tests.

To determine if there were significant differences between students in each program from both universities, a t-test was run for each program on the four Hofstede's dimensions. Table 4 summarizes the results.

Table 4. Comparison of Hofstede's dimensions between the U.S. and Ecuadorian students in each program

		Individualism - Collective		Power Distance		Uncertainty Avoidance		Masculinity - Femininity	
Undergrad Program		**Mean**	**Sig.**	**Mean**	**Sig.**	**Mean**	**Sig.**	**Mean**	**Sig.**
Chemical	US	5.7321	0.369	3.4213	0.246	4.6065	0.963	4.9861	0.000*
	Ecu	5.9063		3.7381		4.5921		5.5921	
Civil & Environmental	US	5.9808	0.386	3.5865	0.522	4.0962	0.464	5.2981	0.697
	Ecu	6.1531		3.7713		4.3188		5.3563	
Computer	US	5.7853	0.129	3.4571	0.290	4.5772	0.422	5.3047	0.279
	Ecu	6.2250		3.9500		5.0000		5.6500	
Electrical	US	5.4387	0.819	3.5729	0.727	4.3417	0.663	5.2750	0.793
	Ecu	5.3542		3.4286		4.1607		5.3393	
Industrial & System	US	5.9091	0.074	3.3586	0.798	3.9271	0.285	5.1007	0.003*
	Ecu	6.1367		3.4153		3.6445		5.5859	
Mechanical	US	5.7781	0.079	3.1686	0.042	4.1905	0.250	5.0863	0.221
	Ecu	6.0710		3.5552		3.9176		5.2471	

(*)Significance at $\alpha/2 = 0.025$

As it is seen from table 4, statistically significant differences were found in the Masculinity – Femininity dimension between universities only in two programs: Chemical engineering and Industrial and Systems engineering.

Also, demographic variables were compared between universities to identify any significant differences in the four dimensions. Table 5 shows these results.

According to results from table 5, Ecuadorian engineering students present more statistically significant differences than the U.S. students. These differences are in:

a. Undergrad program and GPA, in individualism & collectivism dimension
b. Race in power distance dimension.

c. Gender, undergrad program, and respondent's semester highlights statistical differences within the uncertain avoidance dimension, and
d. Respondent’s GPA shows statistical differences within the masculinity - Femininity cultural dimension.

These differences found in Table 4 and Table 5 will be further discussed in our discussion section.

Table 5. Comparison of Hofstede’s dimensions between the U.S. and Ecuadorian students in demographics

	Individualism - Collective		**Power Distance**		**Uncertainty Avoidance**		**Masculinity - Femininity**	
Demographic	US	ECU	US	ECU	US	ECU	US	ECU
Gender	0.174	0.888	0.249	0.206	0.152	0.000	0.643	0.836
Undergrad Program	0.056	0.008	0.427	0.506	0.078	0.006	0.187	0.161
Race	0.070	0.478	0.048	0.121	0.634	0.102	0.347	0.116
GPA	0.765	0.000	0.815	0.199	0.378	0.220	0.675	0.013
Semester	0.177	0.114	0.676	0.048	0.104	0.019	0.529	0.550

Note: Variable gender was tested with T-Student, then null hypothesis was rejected with $\alpha/2 = 0.025$. Other variables were tested with ANOVA of one factor and null hypotheses were rejected with $\alpha = 0.05$.

Discussion

To understand how personal cultural orientation of engineering students compares to Hofstede’s dimensions of National Culture between the U.S. and Ecuador we conducted a quantitative study. Our survey data was analyzed using descriptive and inferential statistics. We wanted to understand if engineering students’ perceptions when responding to the questions would match their national culture data. We compared two institutions that although might look different (a public land-grant research university in the U.S. vs. a private Liberal Arts school in Ecuador) their engineering programs are structured very similar (both institutions follow ABET accreditation requirements). Furthermore, USFQ engineering programs are hosted at the polytechnic institute that has many similitudes to Virginia Tech that is a polytechnic institute and State University.

The first interesting result is that despite the U.S. and Ecuador having very different values of Power Distance, engineering students in both countries had very similar scores in this dimension with no statistically significant difference. Furthermore, the masculinity dimension despite both countries having very similar scores, the data from engineering students was statistically significantly different in this dimension.

In terms of individualism, we were expecting some significant differences, however, we found interesting that Ecuador (6.06) had highest scores than the U.S. (5.7), despite the U.S. having one of the highest scores of individualism (91) and Ecuador having one of the lowest one (8). We consider this result is something that should be explored further to better understand how students are developing their identity as engineers and explore if the curriculum places more value on individual development. For example, one of the majors with the highest differences was computer engineering and industrial and systems engineering. We consider ISE to be a discipline in the United States that traditionally promotes collaboration, hence that might be a reason with U.S. students had lower scores.

Regarding the lack of difference in power distance, despite both countries having very different national scores (78 vs. 40) we think that one of the reasons could be the structure of academic programs in higher education institutions. We can see how both countries have relatively medium scores of power distance. One reason could be that students tend not to question the structure in their engineering classrooms where the professors tend to be the figures that hold power and make decisions with students not having a voice or any input on decision making.

Another dimension that had results we did not expect was the masculinity dimension. In this dimension, Ecuador and the U.S. have very similar scores (62 vs. 63), however, we found statistically significant differences in engineering students from both countries. Ecuador has considerably higher scores in this dimension, especially in chemical engineering and industrial and systems engineering. We wanted to explore if gender was part of the reason for these scores, however, when using gender as the variable to compare this construct there were no significant statistical differences. We also consider that the masculine culture typically prevalent in engineering in South America could have influenced these results.

Conclusions and Future Work

In conclusion, we were expected to see more differences between both countries and see some match of the results to the data from Hofstede on cultural differences at the national level, however, we could see that this was not the case. We can conclude that engineering students share similar perceptions of culture despite their country which makes us argue that the engineering field has a strong dominant culture.

As part of future work, we want to explore these differences qualitatively to obtain a deep understanding of how students perceive their engineering culture.

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