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Understanding Students' perceptions of Dimensions of Engineering Culture in Ecuador

Dr. MiguelAndres Guerra, Universidad San Francisco de Quito USFQ

Professor at Universidad San Francisco de Quito USFQ in Civil Engineering and Architecture

Dr. Homero Murzi, Virginia Tech

Homero Murzi is an Assistant Professor in the Department of Engineering Education at Virginia Tech. He holds degrees in Industrial Engineering (BS, MS), Master of Business Administration (MBA) and in Engineering Education (PhD). Homero has 15 years of international experience working in industry and academia. His research focuses on contemporary and inclusive pedagogical practices, industry-driven competency development in engineering, and understanding the barriers that Latinx and Native Americans have in engineering. Homero has been recognized as a Diggs scholar, a Graduate Academy for Teaching Excellence fellow, a Diversity scholar, a Fulbright scholar and was inducted in the Bouchet Honor Society.

Mr. Johnny Crayd Woods Jr., Virginia Tech

Johnny C. Woods, Jr. is a PhD Student in Higher Education at Virginia Tech (VT), Virginia. He obtained his Master in Educational Foundations from Makerere University and a Bachelor in Sociology from A.M.E. Zion University College. Prior to joining Virginia Tech, he served in several administrative capacities in higher education in Liberia for approximately 11 years. He currently serves as a Graduate Research Assistant in the Department of Engineering Education at VT. His research interests are: Immigrants in STEM, migration and immigration issues in education, and Quality Assurance.

Mr. Abram Diaz-Strandberg, Virginia Tech Department of Engineering Education

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Abstract

The purpose of this study is to explore how engineering students perceive different dimensions associated with culture. We are using Hofstede's theory of dimensions of national cultures to measure culture in different patterns in the student's perceptions of engineering. Data were collected from 147 students during the Fall semester 2019. The students are from a university in Ecuador. The survey was translated into Spanish and was reviewed by several native Spanish speakers. We piloted the survey with several students. The survey was administered online. Results provide preliminary information on how students perceive aspects of culture like individualism, power distance, uncertainty avoidance, and masculinity. We discuss the relationship of these constructs with aspects of the engineering program.

Introduction

Culture represents a set of values and norms that dictate how people behave, interact with each other, learn, shape their personality, and live [1], [2]. Several groups can be described as having a culture. Minkov and Hofstede [3] affirm that the study of culture is the study of meanings. There are elements like symbols, values, norms, beliefs, behaviors, attitudes, self-perceptions, cognitive abilities, and stereotypes [3] that have meaning to specific groups, and through these common elements groups share the same culture.

There is significant engineering education research in the United States on understanding disciplinary engineering culture [4]–[8]. Although culture is considered a complex phenomenon [9]–[11], understanding aspects of it, especially at the disciplinary level, is important to identify paths to improve engineering education in general. For example, understanding how student's perceive different aspects of their engineering major and their identity formation as engineers can help us understand how to develop effective pedagogical and curricular interventions to improve students' performance working with diverse stakeholders [12]. These pedagogical interventions can help students become effective practicing engineers ready to adapt to the challenges of the contemporary workforce. The decision making in the contemporary global world requires mutual understanding among people with different backgrounds and cultures [13]. Understanding disciplinary culture in engineering is also important in order to attract and retain more underrepresented populations into the field. We argue that understanding the dimensions of disciplinary culture in engineering majors can provide a better understanding of: (i) how students develop the skills they consider are necessary to operate in their majors, (ii) how students interact with peers from their same discipline, (iii) how students interact with figures of authority (i.e. faculty members), (iv) how students operate across disciplinary boundaries, (v) how students learn in their discipline, and (vi) how students understand their discipline.

In Ecuador, there has not been much research in engineering education focused on understanding how students perceive the different patterns of cultural traits in engineering majors. Engineering is a really important field in Ecuador as it is considered to be one of the drivers to innovation and -as a consequence- to economic development [14]. The country has increased the number of engineering programs considerably in the last two decades and multiple engineering disciplines are available in the country. The purpose of this study is to explore how engineering students perceive different dimensions of their engineering discipline associated with culture.

Specifically, we are applying Hofstede's original four dimensions of national business cultures (power distance, uncertainty avoidance, individualism, masculinity) [2] to academic disciplines to explain how students develop skills to operate within and across disciplinary boundaries. To do so, we are addressing the following research questions:

1. How do Hofstede's dimensions of national cultures map to academic disciplines in Ecuador?
2. Do students in different majors at a top University in Ecuador have different perceptions of disciplinary cultures according to Hofstede's dimensions?

To answer the research question, we took a quantitative approach. Using a validated survey [15] that measures the different constructs associated with Hofstede's dimensions we collected data on different engineering disciplines at a top University in Ecuador. This study is part of a larger research collaboration in several institutions around the world. In this paper, we report the preliminary results for our partner institution in Ecuador.

Theoretical framework

We are using Hofstede [2] dimensions of national culture as the framework to guide this study. The author developed a series of dimensions to characterize the common traits and beliefs every individual has, with each dimension having two poles. His theory of culture then posits that individuals are located at various points across the spectra of opposite characteristics that comprise each dimension, and individuals with similar characteristics can be grouped under the same type of culture.

Hofstede's theory of cultural dimensions was developed in the mid-1960s, based initially on a survey of IBM employees in more than 40 countries. Hofstede's original analysis yielded four "dimensions," or "values that distinguished countries (rather than individuals) from each other" [2]:

- Power Distance addresses the degree to which those with less power in a given system (workplace, family) may support and expect unequal power distribution;
- Uncertainty Avoidance/Acceptance addresses the degree to which members of a culture can operate comfortably with uncertainty;
- Individualism/Collectivism addresses the relationship between individuals and the larger group; and
- Masculinity/Femininity refers to 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.

Several studies in the past three decades [16]–[26], have used Hofstede's theory to understand culture in different settings and contexts and have confirmed consistency [27], [28] and validity [29], [30] it its use. Therefore, it is possible to argue that Hofstede's framework can be reliable to study cultures and sub-cultures, such as academic engineering disciplines in the context of Ecuador.

Cultural context in Ecuador

Using Hofstede online tool [31], it is possible to obtain an overview of some of the cultural dimensions of people in Ecuador. Figure 1 presents a visual representation of the main dimensions. We included the United States as a reference.

In terms of Power Distance Ecuador has a high rank. 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, therefore, acceptable. Hence, authority power like the military play an important role in political life [31].

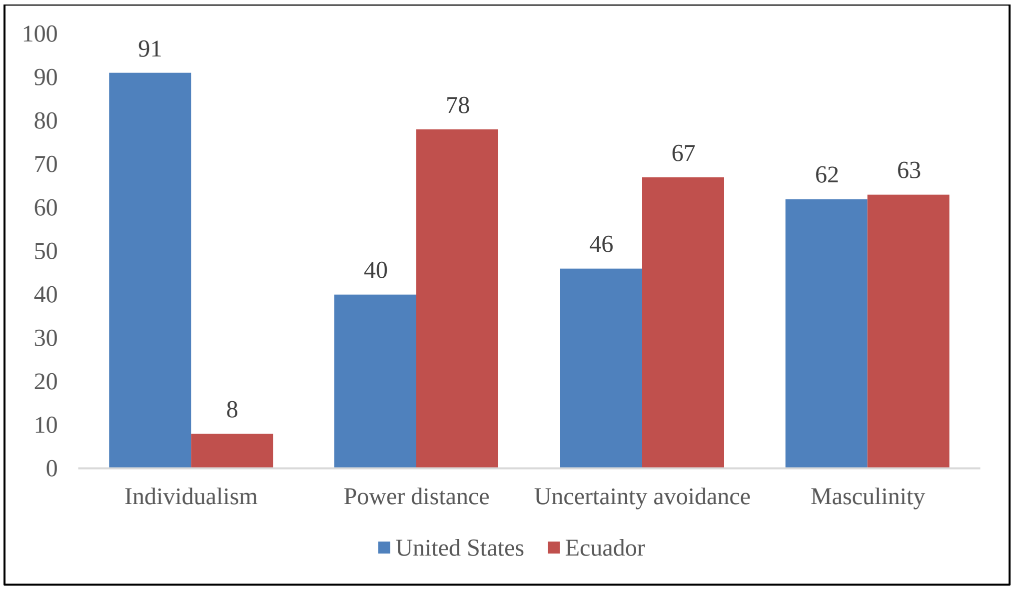

Figure 2. Country comparison between Ecuador and the United States according to Hofstede [31].

Similarly, 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 really important [31]. It also means that when compared to their score in power distance conflict will be avoided in order to maintain the group harmony. In Ecuador, relationships will be prioritized over tasks and cooperative efforts and teamwork become very effective to achieve goals.

In terms of masculinity, a dimension that explains how much a society is driven by competition, achievement, and success, Ecuador ranks in the middle, similar to many countries including the United States. Ecuador is a highly success oriented and driven society, something that contradicts stereotype that many people have about Latin Americans and their avoidance to hard work. Ecuadorians are competitive and status-oriented, though collectivistic rather than Individualist [31].

Finally, in terms of Uncertainty Avoidance and the acceptance to the unknown, Ecuador high score of 67 indicates how they seek to avoid ambiguity. Rules are not necessarily followed, however:

this depends ultimately, on the decision of power holders, who make their own rules, and on whether the group feels the rules are applicable to their members.

This research was conducted at Universidad San Francisco de Quito USFQ, located in the capital of Ecuador, Quito. USFQ is the first Liberal Arts university in Latin America and the only one existing in Ecuador. The university opened its doors in 1988, although it was not officially recognized until 1995. According to the QS University Ranking, USFQ is ranked #1 in Ecuador and #50 in Latin America [32]. The university currently enrolls about six thousand undergraduates and about five hundred graduate students each year. There are about one hundred indigenous students enrolled in the university as part of an aggressive program to promote higher education among minorities [33]. USFQ has an international program through which over one thousand students from all over the world come to study abroad for a semester or a year. Finally, USFQ is the only university in the world that has a campus both on the Galapagos Islands and in the Amazon Jungle Tiputini. Students have the opportunity to visit these campuses and share a research experience with researchers from all over the world [32].

Methods

Data were collected quantitatively using a survey adapted by Sharma [15] to measure Hofstede's cultural dimensions within the engineering majors at USFQ. The survey was administered electronically using the online survey platform Qualtrics. Although the ultimate goal of the project is to collect data from all nine engineering majors during the 2019 – 2020 academic year, this study presents the preliminary results of the data collected during Fall 2019. In the first phase of the study, the survey was administered to 147 students in Civil Engineering (n=39), Industrial and Systems Engineering (n=33), Mechanical Engineering (n=44), Chemical Engineering (n=21), and Food Production Engineering (n=10). All students surveyed were in their third year in their majors. Although the students at USFQ speak English fluently, the local native language of the students is Spanish. In order to avoid any language confusion from the participants, the first step was to translate the survey into Spanish. Then, the researchers proceeded to validate the translation by several native Spanish speakers. Once the translation was validated, it was turned into an online Qualtrics format survey.

The data were processed and managed through Qualtrics and cleaned in Excel. The results obtained from the participants were analyzed using Minitab software. Data from 147 participants in 5 different engineering majors were analyzed. The analysis to determine if the differences in cultural dimension scores among majors were statistically significant consisted of two steps. The first step was to conduct an ANOVA (f-test) to search for statistically significant differences among the results. If there were statistically significant differences, then we conducted both a Tukey and a Fisher post-hoc analysis to determine which engineering scores were different [34]. The Tukey analysis is a more conservative approach when it comes to stating differences between scores, while the Fisher analysis is more liberal. The researchers used both post-hoc approaches in this early stage of the study in order to not rule out any potential differences that may carry important significance, as well as to be aware of which majors are more likely to remain different. The students' responses were clustered by each of the five engineering majors, and the four Hofstede dimensions were measured through a 7-point Likert scale.

The first dimension measured is Individualism, which groups the questions under Independence and Interdependence. The higher the score (maximum 7), the more individualistic the individual is. The second dimension is Power Distance, which groups the questions under Power and Social Inequality. The lower the score (minimum 1), the less comfortable the individual is with hierarchies in human interaction. The third-dimension measures Uncertainty Avoidance, which groups the questions under Risk Avoidance and Ambiguity Intolerance. The higher the score (maximum 7), the less comfortable the individual is with uncertainty. The fourth dimension is Masculinity, which groups the questions under Masculinity and Gender Equality. The lower the score (minimum 1), the better disposition towards femininity.

To assess the quality of the research, the study stands on previous studies conducted by one of the authors [4], [6], [35]. Content validity was discussed and determined by the researchers in consensus [36]. 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 [24], [29], [30], [37], [38] and the authors even demonstrated its validity in academic settings [4].

Results and Discussion

The overview of the results of the survey for the five engineering majors are presented in table 1. For each major, the sample size, arithmetic mean and standard deviation for each of Hofstede's four Cultural Dimensions are presented. The rest of the section presents the analysis using inferential statistics to determine if the difference across the student responses for every dimension is statistically significant.

Table 1. Arithmetic mean and standard deviation of responses for cultural dimensions

Engineering major	**n**	**Cultural Dimensions**							
		Individualism		**Power Distance**		**Uncertainty Avoidance**		**Masculinity**	
		Mean	**St. Dev**	**Mean**	**St. Dev**	**Mean**	**St. Dev**	**Mean**	**St. Dev**
Civil Engineering (ICV)	39	6.1836	0.3952	3.6820	0.8710	4.3190	0.9260	5.3930	0.7540
Industrial and Systems Engineering (IIN)	33	6.1352	0.3719	3.3640	0.9830	3.6890	1.0720	5.5582	0.5695
Mechanical Engineering (IME)	44	6.0739	0.5246	3.4810	0.8280	3.9200	1.1550	5.2284	0.6453
Chemical Engineering (IQUI)	21	5.8870	0.7330	3.7210	0.9840	4.5370	1.0130	5.5950	0.5640
Food Production Engineering (IAL)	10	5.7020	0.9480	3.6160	0.7270	4.6640	1.4650	5.2770	0.6510
Total Participants	**147**								

Note: The dimensions were measured on a 1-7 Likert scale.

Cultural Dimensions

The mean scores presented in table 1 show that the student responses of each dimension are similar across the five engineering majors. For the Individualism dimension, the students across the five majors placed their answers around 6 in the scale, placing students in the high end of construct. These are very high values of individualism that contrast with the low national scores in this dimension, presented earlier. The national score places Ecuadorians in the high end for being a collectivistic society. Thus, this score is something to consider once the full data set is gathered. For the Power Distance dimension, the students across the five majors placed their answers around 3.6 in the scale, placing students in the middle of being comfortable with clearly defined hierarchies. The national score places Ecuadorians in the middle-high end for this dimension. The difference with the national score was expected, because the participants are college students at a top private university. For the Uncertainty Avoidance dimension, the students across the five majors placed their answers around 4.3 in the scale, placing students in the middle-high end of seeking to avoid the unknown. The national score places Ecuadorians similarly in the spectrum. And for the Masculinity dimension, the students across the five majors placed their answers around 5.2 in the scale, placing students on the higher end of being driven by competition, achievement and success. The national score places Ecuadorians in the middle-high end for this dimension. Although there is a difference in the scores, both show a higher score in this dimension. The following paragraphs describe in detail the scores in each dimension, as well as the different statistical tests conducted to identify if there were significant differences in the responses.

Individualism

A summary of the responses across the five engineering majors for the Individualism dimension is presented in table 2. Overall, the five major responses have a high score towards the high independence end. Civil Engineering (M=6.1836, SD=0.3952) and Industrial and Systems Engineering (M=6.1352, SD=0.3719) show the highest scores, while Chemical Engineering (M=5.8870, SD=0.7330) and Food Production Engineering (M=5.7020, SD=0. 9480) show the lowest scores.

Table 2. Scores for Individualism dimension

Engineering major	**n**	**Mean**	**St. Dev**	**95% CI**
Civil Engineering (ICV)	39	6.1836	0.3952	(6.0134, 6.3538)
Industrial and Systems Engineering (IIN)	33	6.1352	0.3719	(5.9502, 6.3201)
Mechanical Engineering (IME)	44	6.0739	0.5246	(5.9137, 6.2341)
Chemical Engineering (IQUI)	21	5.8870	0.7330	(5.6550, 6.1190)
Food Production Engineering (IAL)	10	5.7020	0.9480	(5.3660, 6.0380)
Total participants	**147**			

Note: The dimensions were measured on a 1-7 Likert scale.

Conducting the ANOVA (f-test) between the five majors resulted on an F-value of 2.340 (< 2.384 critical value) and a p-value of 0.058 (> 0.05), thus we reject the null hypothesis. Then, the researchers conducted the Tukey and Fisher pairwise comparisons. The Tukey pairwise comparison results showed that there not statistically significant difference among the five engineering majors. On the other hand, the Fisher pairwise comparison showed that a statistically significant difference occurs when comparing Civil Engineering vs. Chemical Engineering, Civil Engineering vs. Food Production Engineering, and Industrial Engineering vs. Food Production Engineering. The meaning of these results is, for example, that we can say with 95% confidence, that Civil Engineering students are less dependent or more individualistic than Chemical Engineering and Food Production Engineering students. Figure 2 shows (a) the Tukey pairwise comparison, (b) the Fisher pairwise comparison, and (c) the major relationships that present scores with a statistically significance different.

Tukey Pairwise Comparisons

Factor	N	Mean	Grouping
ICV	39	6.1836	A
IIN	33	6.1352	A
IME	44	6.0739	A
IQUI	21	5.887	A
IAL	10	5.702	A

Means that do not share a letter are significantly different.

(a)

Fisher Pairwise Comparisons

Factor	N	Mean	Grouping		
ICV	39	6.1836	A		
IIN	33	6.1352	A	B	
IME	44	6.0739	A	B	C
IQUI	21	5.887		B	C
IAL	10	5.702			C

(b)

01 - INDIVIDUALISM - 95%		
Majors	**TUKEY**	**FISHER**
ICV - IIN	NO difference	NO difference
ICV - IME	NO difference	NO
ICV - IQUI	NO difference	YES, Significant difference
ICV - IAL	NO difference	YES, Significant difference
IIN - IME	NO difference	NO
IIN - IQUI	NO difference	NO
IIN - IAL	NO difference	YES, Significant difference
IME - IQUI	NO difference	NO
IME - IAL	NO difference	NO
IQUI - IAL	NO difference	NO

(c)

Figure 2. Statistical analysis for engineering major comparisons in Individualism dimension

Power Distance

A summary of the responses across the five engineering majors for the Power Distance dimension is presented in table 3. The five major responses have a medium score, situating these students in a balance about comfort to hierarchies. Although slightly, Chemical Engineering students (M=3.7210, SD=0.9840) show the highest scores, while Industrial and Systems Engineering students (M=3.3640, SD=0.9830) show the lowest scores. Those scores show that the five majors under study are close one another in the middle of the Power Distance dimension.

Table 3. Scores for Power Distance dimension

Engineering major	n	Mean	St. Dev	95% CI
Civil Engineering (ICV)	39	3.6820	0.8710	(3.399, 3.965)
Industrial and Systems Engineering (IIN)	33	3.3640	0.9830	(3.057, 3.672)
Mechanical Engineering (IME)	44	3.4810	0.8280	(3.214, 3.747)
Chemical Engineering (IQUI)	21	3.7210	0.9840	(3.336, 4.106)
Food Production Engineering (IAL)	10	3.6160	0.7270	(3.058, 4.174)
Total participants	147			

Note: The dimensions were measured on a 1-7 Likert scale.

Conducting the ANOVA (f-test) between the five majors resulted on an F-value of 0.84 (< 2.384 critical value) and a p-value of 0.501 (> 0.05), lead us to accept the null hypothesis, meaning the scores are equal. The Tukey and Fisher pairwise comparisons confirm the conclusions by showing not statistically significant difference among the five engineering majors. For example, after conducting the statistical analysis, we can say with 95% confidence that Industrial and Systems Engineering students and Mechanical Engineering students are in the same range of the Power Distance dimension. Figure 3 shows (a) the Tukey pairwise comparison, (b) the Fisher pairwise comparison, and (c) the differences between the five majors with scores that do not present statistically significance.

Tukey Pairwise Comparisons

Factor	N	Mean	Grouping
IQUI	21	3.721	A
ICV	39	3.682	A
IAL	10	3.616	A
IME	44	3.481	A
IIN	33	3.364	A

Means that do not share a letter are significantly different.

(a)

Fisher Pairwise Comparisons

Factor	N	Mean	Grouping
IQUI	21	3.721	A
ICV	39	3.682	A
IAL	10	3.616	A
IME	44	3.481	A
IIN	33	3.364	A

(b)

02 - POWER DISTANCE - 95%		
Majors	**TUKEY**	**FISHER**
ICV - IIN	NO difference	NO difference
ICV - IME	NO difference	NO difference
ICV - IQUI	NO difference	NO difference
ICV - IAL	NO difference	NO difference
IIN - IME	NO difference	NO difference
IIN - IQUI	NO difference	NO difference
IIN - IAL	NO difference	NO difference
IME - IQUI	NO difference	NO difference
IME - IAL	NO difference	NO difference
IQUI - IAL	NO difference	NO difference

(c)

Figure 3. Statistical analysis for engineering major comparisons in Power Distance dimension

<u>Uncertainty Avoidance</u>

A summary of the responses across the five engineering majors for the Uncertainty Avoidance dimension is presented in table 4. Overall, the five major responses have a medium-high score towards the less comfortable with uncertainty end. Food Production Engineering (M=4.664, SD=1.465) and Chemical Engineering (M=4.537, SD=1.013) show the highest scores, while Industrial and systems Engineering (M=3.689, SD=1.072) and Mechanical Engineering (M=3.920, SD=1.155) show the lowest scores.

Conducting the ANOVA (f-test) between the five majors resulted on an F-value of 3.42 (> 2.384 critical value) and a p-value of 0.011 (< 0.05), thus we reject the null hypothesis. Then, the researchers conducted the Tukey and Fisher pairwise comparisons. The Tukey pairwise comparison results showed one statistically significant difference when comparing Industrial Engineering vs. Chemical Engineering among the five engineering majors The Fisher pairwise comparison showed that a statistically significant difference occurs when comparing Civil Engineering vs. Industrial Engineering, Industrial Engineering vs. Chemical Engineering, and Industrial Engineering vs. Food Production Engineering.

Table 4. Scores for Uncertainty Avoidance dimension

Engineering major	n	Mean	St. Dev	95% CI
Civil Engineering (ICV)	39	4.319	0.926	(3.976, 4.662)
Industrial and Systems Engineering (IIN)	33	3.689	1.072	(3.316, 4.061)
Mechanical Engineering (IME)	44	3.920	1.155	(3.598, 4.243)
Chemical Engineering (IQUI)	21	4.537	1.013	(4.070, 5.004)
Food Production Engineering (IAL)	10	4.664	1.465	(3.987, 5.341)
Total participants	147			

Note: The dimensions were measured on a 1-7 Likert scale.

The meaning of these results is, for example, that we can say with 95% confidence, that Industrial Engineering students are less comfortable with uncertainty than Food Production Engineering. Figure 4 shows (a) the Tukey pairwise comparison, (b) the Fisher pairwise comparison, and (c) the major relationships presenting scores with a statistically significance different.

Tukey Pairwise Comparisons

Factor	N	Mean	Grouping	
IAL	10	4.664	A	B
IQUI	21	4.537	A	
ICV	39	4.319	A	B
IME	44	3.920	A	B
IIN	33	3.689		B

Means that do not share a letter are significantly different.

(a)

Fisher Pairwise Comparisons

Factor	N	Mean	Grouping		
IAL	10	4.664	A	B	
IQUI	21	4.537	A		
ICV	39	4.319	A	B	
IME	44	3.920		B	C
IIN	33	3.689			C

(b)

03 - UNCERTAINTY AVOIDANCE - 95%		
Majors	TUKEY	FISHER
ICV - IIN	NO	YES, Significant difference
ICV - IME	NO	NO
ICV - IQUI	NO	NO
ICV - IAL	NO	NO
IIN - IME	NO	NO
IIN - IQUI	YES, Significant difference	YES, Significant difference
IIN - IAL	NO	YES, Significant difference
IME - IQUI	NO	NO
IME - IAL	NO difference	NO difference
IQUI - IAL	NO difference	NO difference

(c)

Figure 4. Statistical analysis for engineering major comparisons in Uncertainty Avoidance dimension

<u>Masculinity</u>

A summary of the responses across the five engineering majors for the Masculinity dimension is presented in table 5. Overall, the five major responses have a high score towards the high masculinity end. Although Chemical Engineering students (M=5.595, SD=0.564) show the highest scores, while Mechanical Engineering students (M=5.2284, SD=0.6453) and Food Production Engineering students (M=5.277, SD=0.651) show the lowest scores, the differences among their means are minimum. Those scores show that the five majors under study lean towards being driven by competitive, achievements, and success.

Table 5. Scores for Masculinity dimension

Engineering major	n	Mean	St. Dev	95% CI
Civil Engineering (ICV)	39	5.393	0.754	(5.187, 5.600)
Industrial and Systems Engineering (IIN)	33	5.5582	0.5695	(5.3339, 5.7825)
Mechanical Engineering (IME)	44	5.2284	0.6453	(5.0342, 5.4227)
Chemical Engineering (IQUI)	21	5.595	0.564	(5.299, 5.890)
Food Production Engineering (IAL)	10	5.277	0.651	(4.870, 5.684)
Total participants	147			

Note: The dimensions were measured on a 1-7 Likert scale.

Conducting the ANOVA (f-test) between the five majors resulted on an F-value of 1.76 (< 2.384 critical value) and a p-value of 0.14 (> 0.05), thus we accept the null hypothesis. Then, the researchers conducted the Tukey and Fisher pairwise comparisons. The Tukey pairwise comparison results showed that there not statistically significant difference among the five engineering majors. The Fisher pairwise comparison showed that a statistically significant difference occurs when comparing Industrial Engineering vs. Mechanical Engineering and Mechanical Engineering vs. Chemical Engineering. The meaning of these results is, for example, that we can say with 95% confidence, that Mechanical Engineering students are less driven by competition than Industrial Engineering.

Tukey Pairwise Comparisons

Factor	N	Mean	Grouping
IQUI	19	5.595	A
IIN	33	5.5582	A
ICV	39	5.393	A
IAL	10	5.277	A
IME	44	5.2284	A

Means that do not share a letter are significantly different.

(a)

Fisher Pairwise Comparisons

Factor	N	Mean	Grouping	
IQUI	19	5.595	A	
IIN	33	5.5582	A	
ICV	39	5.393	A	B
IAL	10	5.277	A	B
IME	44	5.2284		B

(b)

04 - MASCULINITY - 95%		
Majors	TUKEY	FISHER
ICV - IIN	NO	NO
ICV - IME	NO	NO
ICV - IQUI	NO	NO
ICV - IAL	NO	NO
IIN - IME	NO	YES, Significant difference
IIN - IQUI	NO	NO
IIN - IAL	NO	NO
IME - IQUI	NO	YES, Significant difference
IME - IAL	NO difference	NO difference
IQUI - IAL	NO difference	NO difference

(c)

Figure 5. Statistical analysis for engineering major comparisons in Masculinity

Figure 5 shows (a) the Tukey pairwise comparison, (b) the Fisher pairwise comparison, and (c) the major relationships presenting scores with a statistically significance different.

Cultural Dimensions similarities and differences across Engineering Majors

Table 6 presents a comparison of similarities and differences across the five engineering majors by the four Cultural Dimensions. There are six comparisons that present only one significant difference. Civil Engineering students present differences in Uncertainty Avoidance with respect to Industrial and Systems Engineering and Mechanical Engineering students, and in Individualism with respect to Chemical and Food Production Engineering students. Industrial and Systems Engineering students show a significant difference in Masculinity with Mechanical Engineering students, and in Uncertainty Avoidance with Chemical Engineering students.

There are three comparisons that present two significant differences. Mechanical Engineering students present a significant difference in Uncertainty Avoidance and Masculinity with Chemical Engineering students, and in Individualism and Uncertainty Avoidance with Food Production Engineering students. Industrial and Systems Engineering students present a significant difference in Individualism and Uncertainty Avoidance with Food Production Engineering students. The comparison between Chemical Engineering students and Food Production Engineering students shows no significant difference.

Understanding the cultural dimensions that are similar among majors is a strength for future collaborations in the professional world. Similarly, understanding the differences among the cultural dimensions can be an opportunity to develop pedagogical interventions that strengthen the understanding of other peers in the professional world.

Table 6. Cultural Dimensions similarities and differences across Engineering Majors

Majors	**Cultural Dimensions**			
	Significant difference		**No difference**	
Civil vs Industrial and Systems	1	UA	3	IND, PD, MAS
Civil vs Mechanical	1	UA	3	IND, PD, MAS
Civil vs Chemical	1	IND	3	PD, UA, MAS
Civil vs Food Production	1	IND	3	PD, UA, MAS
Industrial and Systems vs Mechanical	1	MAS	3	IND, PD, UA
Industrial vs Chemical	1	UA	3	IND, PD, MAS
Industrial vs Food Production	2	IND, UA	2	PD, MAS
Mechanical vs Chemical	2	UA, MAS	2	IND, PD
Mechanical vs Food Production	2	IND, UA	2	PD, MAS
Chemical vs Food Production	0	-	4	ID, PD, UA, MAS

UA= Uncertainty Avoidance, IND= Individualism, PD= Power Distance, MAS= Masculinity

Conclusions

This study shows the data collected in Fall 2019 at a Liberal Arts university in Ecuador, which is the first part of a larger study. Cultural Dimensions scores vary among engineering majors. However, they are very similar overall. Although the participants were from Ecuador, we found it interesting that the results of the survey in some dimensions were different to what Hofstede's theory says about Ecuadorian culture. Although we are not comfortable making any claims at this exploratory stage of our research, we consider that this is something that requires further exploration. Maybe the students that select engineering as their career path have a unique way of thinking and their engineering culture is stronger than their national culture. For example, students in engineering might perceive that their work is more individualistic, hence the misalignment with the highly collectivistic societal norm.

Understanding the cultural dimensions characteristics of a major, and how they differ from the cultural dimensions of the location of the student, helps to visualize the effects of the engineering major on the individual. With the current data, we observed that students from all five majors were high in individualism, while Ecuadorians as a whole have very collectivistic values. In fact, Ecuador ranks as having the second strongest collectivistic values in the world [33]. These surprising scores may be supported by the western educational system where completing a major is based mainly on assessments of the individual's knowledge rather than the knowledge a group can build [38]. Students scored similarly to their country rankings in other cultural traits regardless of the students' areas of study. For example, students from the five engineering majors scored similarly to Ecuador´s country ranking for the Uncertainty Avoidance dimension.

One of the dimensions that posed more significant differences between the majors was uncertainty avoidance. We found consider this is for several reasons. First, there are different disciplinary perceptions and motivations regarding accepting risks. For example, disciplines like industrial and systems engineering have relatively low uncertainty avoidance [39] because of the many different career paths students can take and how flexible is the discipline in terms of the type of problems they solve. In contrast, disciplines like Civil Engineering are required to have less acceptance of uncertainty because of the type of work they do [40], [41]. There are is no room for leaving things uncertain when designing a building for example. Understanding this is important when training students on how to collaborate with other engineers. For students with high acceptance of uncertainty is important to understand that engineers from other disciplines might not be comfortable with not having a clear plan. It is important that they understand how to structure their acceptance to uncertainty by developing some structured working plans that include deadlines, responsible, and expected solutions for example.

Similarly, another dimension that presented significant differences between the engineering disciplines was individualism. We consider this result to be important and that has several implications for how engineering students will operate across disciplines. Research suggest that engineering students tend overall to be more individualistic [6], [39], [42]. Part of this characteristic comes from the fact that early in their academic programs, engineering student courses tend to focus on more individualistic learning (e.g. math, chemistry, dynamics) where students are evaluated by individual tests. Team projects are introduced later in their disciplines and there are multiple disciplines that have considerably less exposure to teamwork (e.g., mechanical vs. industrial) [43], [44]. We consider this to also be an important finding since we can recommend that despite the discipline engineering programs promote an integrate more team projects. We do not consider the engineering field should be an individualistic one as most engineering solutions require of the collaboration of people from different disciplines and different backgrounds. Promoting team-based learning, emphasizing the importance of multiple points of views when solving problems, exposing engineering students to work in projects with students from other disciplines are some of the recommendations we consider from this research.

Identifying the Cultural Dimensions that are similar among engineering majors can be a strength to guide future collaborations in the professional world. Similarly, identifying the Cultural Dimensions that are different among engineering majors can be an opportunity to develop pedagogical interventions that strengthen empathy and collaborative work with different peers in the professional world.

Limitations

This study is the first phase of a more comprehensive study of Hofstede's cultural dimensions among engineering majors in a Liberal Arts university in Ecuador. The data set is still small compared to the size of the engineering student population at USFQ. This issue will be addressed once the full data set is collected. Although there will be a larger data set, the researchers will be careful with any generalization from the study. Another important limitation to note is that the study does not consider how students interact among other majors or other disciplines. Hence, it is just a descriptive representation of their perceptions based on Hofstede's dimensions. Understanding how students interact within engineering disciplines and outside their engineering boundaries (e.g. engineering vs. business) is out of the scope of this exploratory study.

Future work

This exploratory study provided preliminary results on the students' perceptions of the dimensions of disciplinary culture in Ecuador. We consider this work relevant to allow us to better understand the context of one institution. We plan to continue this research in different ways. First, we want to explore how other are students' perceptions of their engineering major in different types of institutions. Furthermore, the research team has been collecting data in different countries and we aspire to report on the major differences/similitudes among countries. One of our goals is to identify if national cultures are more predominant than engineering cultures.

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