EXPLORING STUDENTS' PERCEPTIONS OF ENGINEERING CULTURE: A COMPARATIVE ANALYSIS BETWEEN CHILE, COLOMBIA, ECUADOR, AND THE UNITED STATES

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ABSTRACT

Several studies have explored engineering culture in terms of how it is perceived by engineers, students, or faculty members. However, less is known about how engineering culture varies (or not) when considering national culture as the lens. This study aims to explore how engineering students perceive different dimensions of national culture and identify any patterns that connect to how they perceive their engineering programs. We use Hofstede's theory of dimensions of national cultures to measure culture in different ways in the student's perceptions of engineering. Data were collected using a validated survey that explores dimensions of culture and the sample included engineering students from Chile, Colombia, Ecuador, and the

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United States. The survey was translated into Spanish and was reviewed by several native Spanish speakers. We piloted the survey with several students. Data were analyzed using descriptive and inferential statistics. Results provide preliminary information on how students perceive aspects of culture like individualism, power distance, uncertainty avoidance, and masculinity. We discuss the comparison of the different countries and provide implications of these results to our understanding of engineering culture.

1 INTRODUCTION

1.1 Background

Given the central role engineering plays in technology and innovation, 21st-century engineering programs have been consistently called upon to help students develop the attitudes, mindsets, and practices that can drive innovation [1]–[4]. Similarly, the globalization of the contemporary world requires that those engineering competencies include a global perspective [5]–[7]. Culture, in this case, can be a lens that helps engineering programs understand barriers to transforming curricula, emphasizing the importance of innovation and global awareness in engineering curricula to drive knowledge-based economic competitiveness.

In this study, we focus on these issues via an exploration of culture in engineering. This approach is consistent with Matusovich et al.'s [8] argument that not only personal but collective beliefs and values are also essential in supporting change. As Godfrey et al., [9] note, calls to address change in engineering education through a cultural lens date back at least to the mid-1990s and encompass studies of national cultures, institutional and campus cultures, faculty cultures, gender, and more. Culture has been a prominent framework used with minoritized groups, particularly women, in engineering. Diverse perspectives in engineering are considered to drive innovation and global awareness, however, there is a lack of diversity in the field often attributed to cultural traits of the discipline, characterized as masculine, individualistic, and function-oriented [10]–[15].

In addition to specific work on the culture of engineering, several studies have looked at differences in academic disciplines with respect to teaching, learning, and practice. One of the earliest and most notable is Snow [16]'s Two Cultures, positing the growing divide between the "literary intellectuals" and the "physical scientists." Since then, a range of social science and education researchers have used empirical research to explore differences and similarities among disciplines more fully. Work by Becher [17], [18] focused on analyzing disciplinary differences from the micro-level (academic departments). Bradbeer [19] looked to the macro-level (interaction of different disciplines) with work based on understanding differences in disciplinary epistemologies, discourses, traditions for teaching and learning, and students' preferred learning approaches. Donald's [20] case studies examined structures professors and students create to construct and use knowledge. Nulty and Barrett [21] focused on experiential learning models. Neumann et al. [22] examined the

nature of teaching, teaching and learning processes, and teaching outcomes across the different disciplines to propose broader disciplinary classifications.

As noted earlier, our particular interest in disciplinary cultures emerges from two intersecting needs: to help engineering students develop as innovators and to expand global awareness in the field. And, we argue, these two needs are intertwined. While existing work on engineering culture highlights several issues regarding the culture of the discipline, that work does not typically intersect with work on cultures that consider national differences. Similarly, much of the work on disciplinary culture seeks to describe differences in ways of knowing and learning but does not necessarily link those epistemologies to particular values or beliefs. Carberry and Baker [23] explain that cultural considerations in engineering and engineering education spotlight the importance of culture and its implications on learning, teaching, engineering practice, identity, and enculturation as an engineer. We argue that understanding our national culture's influence on the way we perceive our disciplinary culture is essential and has not been studied extensively in engineering education.

1.2 Purpose

The purpose of this exploratory paper is to present preliminary results of a larger study being conducted with engineering students in different countries around the world to compare how their national culture influences (or not) the way they perceive their disciplinary culture. In this paper, we report the results of a survey conducted in universities in Colombia, Chile, Ecuador, and the United States with undergraduate engineering students. Our overarching research question is: Are there any differences in the way students perceive their engineering culture in different countries?

In the following sections, we describe the theoretical framework used to shape this work, the context of the research in terms of the cultural differences among the countries studied, and the institutional context of the participants. Finally, we report our results and provide some discussion of our findings and directions for our future work.

2 EXPLORATION OF THE LITERATURE

2.1 Hofstede

To understand how national culture influences the perceptions of engineering culture students have, we used Hofstede's [24] theory of dimensions of national culture to guide our work. Hofstede's [24]–[28] theory has been one of the most cited around countries' cultural differences. His work started in the mid-1960s when he surveyed employees at IBM -with similar working conditions and responsibilities- in more than 50 countries. The survey explored employees' values, and the information helped him identify the different dimensions in a culture that can demonstrate differences across countries. Hofstede [26] defined culture based on his data and explained that cultural patterns are rooted in the value system of major groups of individuals and

became stabilized over long periods as the acceptable way of thinking. This includes patterns of thinking, feeling, and acting that every human being carries and that usually people will collectively share as the appropriate way of thinking based on where they are from. These patterns are created by social interactions and experiences collected since the early life of an individual, starting “within the family; it continues within the neighborhood, at school, in youth groups, at the workplace, and in the living community” [28] (p. 6). Hofstede’s [26] original dimensions of culture are:

- **Power Distance** addresses the degree to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally.
- **Uncertainty Avoidance/Acceptance** addresses how members of a culture can operate comfortably with uncertainty.
- **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.
- **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.

Our study compares different countries in the world that are culturally different in terms of these dimensions. This paper focuses on Chile, Colombia, Ecuador, and the United States. Using Hofstede's online tool [29], it is possible to obtain an overview of some of the cultural dimensions of people in the countries we studied. Figure 1 presents a visual representation of the main dimensions.

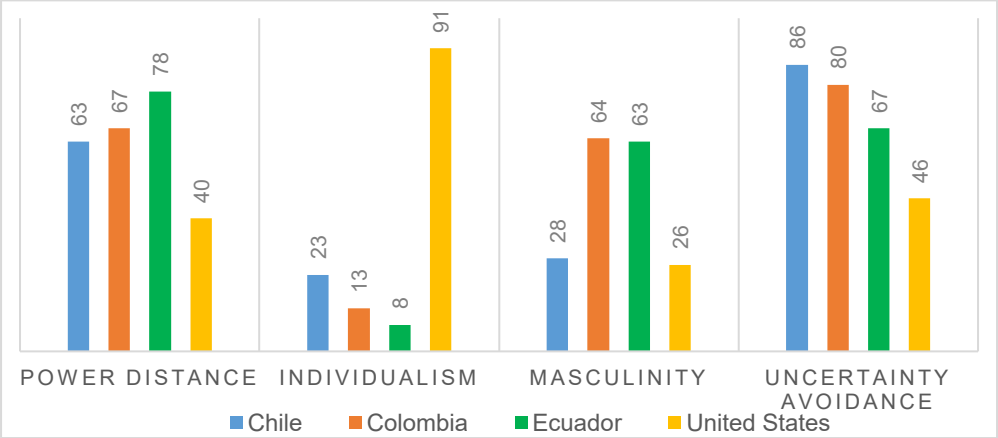

Fig. 1. Cultural comparison between the four countries in this study

From Figure 1, it is possible to see that, in terms of Individualism, the United States has one of the most individualistic societies. In contrast, Ecuador has one of the less individualistic ones. In terms of Power Distance, Ecuador has a very high power distance, Colombia and Chile are in the middle, and the United States has a relatively low one. Masculinity is also divided between Chile and the United States (low) and Colombia and Ecuador (high). Finally, uncertainty avoidance also has a significant division having Chile with the highest one followed by Colombia, Ecuador

ranking in the middle, and the United States having a relatively low uncertainty avoidance.

3 METHODOLOGY

3.1 Context for the study

The study was conducted on 4 institutions in the different countries. In Colombia, the Technological University of Pereira it's a technical institution with 17971 students. The University has 93 academic programs. There are 6199 engineering students and 10 different engineering programs. In Chile, Austral University has 16893 students distributed among 52 academic degrees. There are 8 engineering programs with a. total of 2424 undergraduate engineering students. The University San Francisco de Quito in Ecuador is a private university located in Quito Ecuador and has about 7000 undergraduate students. Virginia Tech, in the United States, 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 offers 14 undergraduate degree-granting engineering majors.

3.2 Data collection

To better understand the differences between engineering cultural perceptions of engineering students from Chile, Colombia, Ecuador, and the United States, data were collected quantitatively using a survey adapted by Sharma [30] to measure Hofstede's cultural dimensions within engineering students. This survey was validated by Sharma [30], but the authors also validated it for its use in academic disciplines [31].

Sharma's survey 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" ([30], 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 concerning social roles, capabilities, rights, and responsibilities.

The survey was administered electronically using Google forms. It was distributed in all participating institutions in the four countries. The survey was translated into Spanish and piloted with experts. Participants included 131 Engineering students from Chile, 85 engineering students from Colombia, 167 engineering students from Ecuador, and 211 engineering students from the United States

Data were analyzed for initial differences, and in this paper, we present our preliminary results to show some of the differences between the countries selected. In the following section, we report on the mean for each of the constructs to show the general differences in each of those. In the next section, we provide some discussion.

4 RESULTS

4.1 Individualism-Collectivism

In individualism-collectivism (figure 2), Ecuadorian students reported being the more individualistic ones. These results are significantly different, with 95% confidence using the Tukey method. However, all countries have relatively high perceptions of this construct.

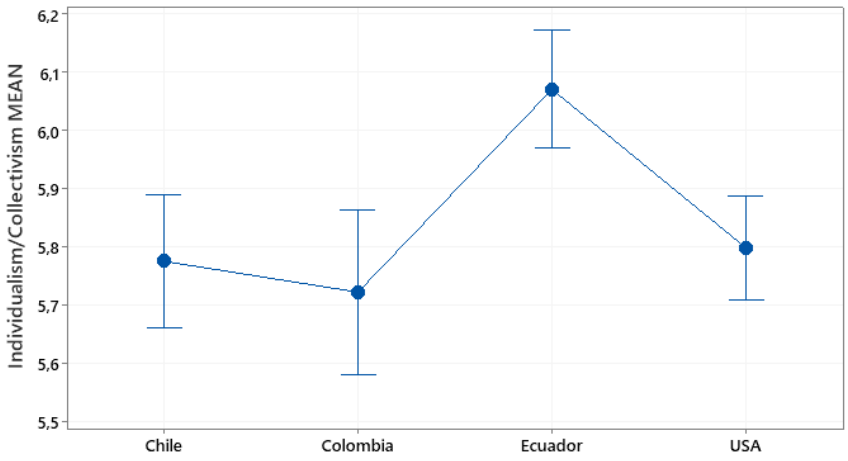

Fig. 2. Results for Individualism

4.2 Power Distance

In Figure 3, it is possible to observe that Colombia has the lowest Power Distance and Ecuador has the highest one, although all countries have a relatively low power distance perception.

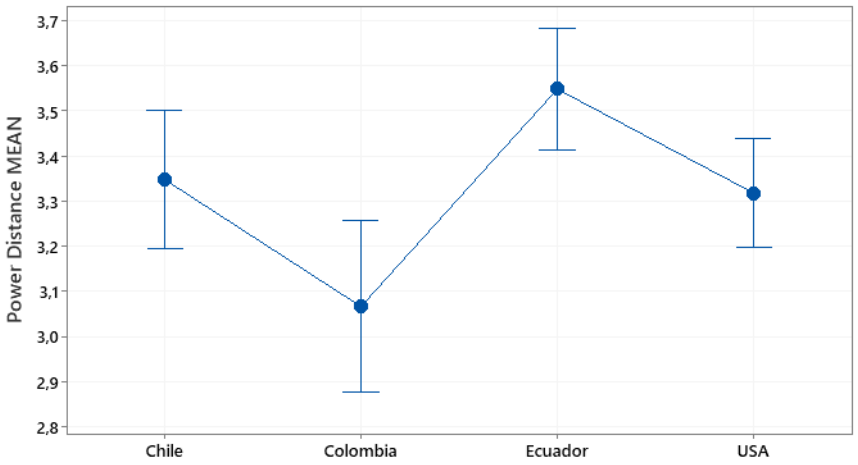

Fig. 3. Results for Power Distance

4.3 Uncertainty Avoidance

Regarding Uncertainty avoidance (figure 4), Chile ranks higher than other countries, and Colombia has the lowest one. All countries rank in the middle for this construct.

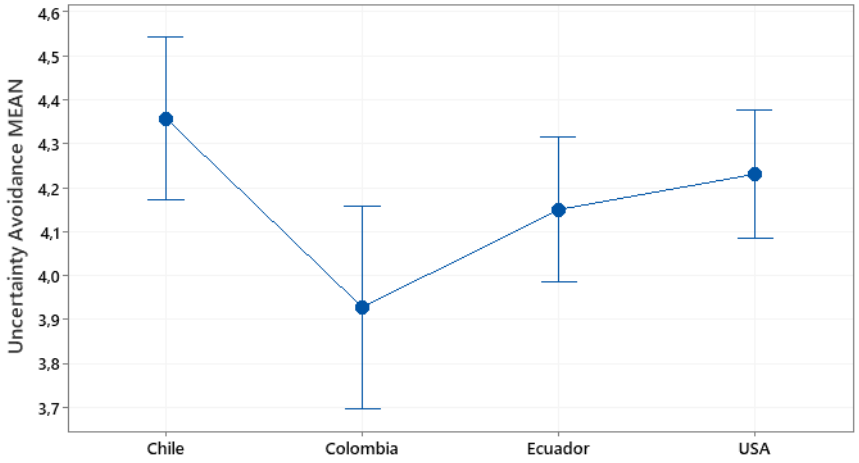

Fig. 4. Results for Uncertainty Avoidance

4.4 Masculinity – Femininity

There are no significant differences in this masculinity-femininity (figure 5), with all countries ranking high.

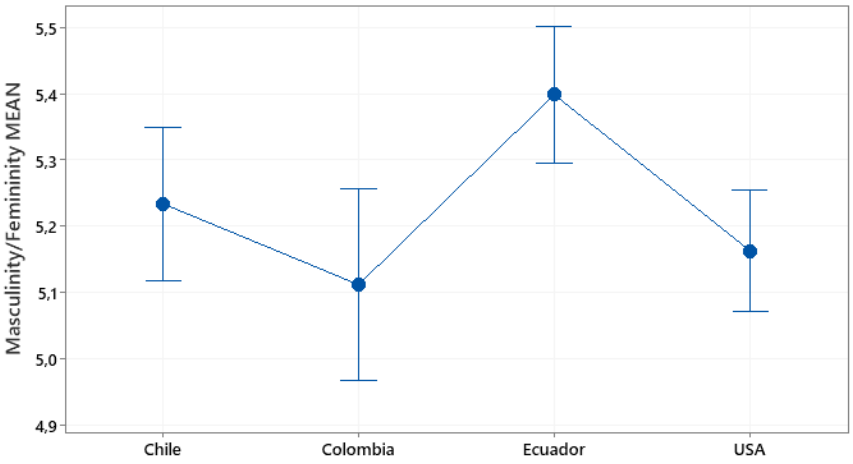

Fig. 5. Results for Uncertainty Avoidance

5 DISCUSSION

To understand the differences and similarities in engineering students' perceptions of engineering culture concerning Hofstede's dimensions of National Culture between Chile, Colombia, Ecuador, and the United States, we conducted a quantitative study. Our survey data were analyzed using descriptive and inferential statistics. We wanted to understand if engineering students' perceptions would match their national culture data when responding to the questions. We compared four institutions that, although they might look different, their engineering programs are structured very similarly.

The first interesting result is regarding individualism. Despite all 3 South American countries being very collectivistic cultures and the United States having one of the more individualistic societies, in our data, students in all countries report considerably high in individualism. Furthermore, Ecuador is one of the most collectivistic societies. However, in our data, students reported the highest perceptions of individualism. This result is interesting and worth exploring further to understand if the way that engineering programs are structured is fomenting the prevalence of individualism over collectivism, for example, the high focus on grades and the importance of finding the right solution -typical in an engineering culture- could be motivating this perception.

We were expecting some significant differences in terms of power distance, as Ecuador has one of the highest power distance indexes and the United States a relatively low one, having Chile and Colombia ranking in between. Our data confirm this finding; however, in general, our results show that all countries are ranking in the middle in power distance. Having Colombian students ranking the lowest and Ecuador, as expected, ranking the highest. It was also surprising to see the United States ranked the second-highest, despite the country having a lower power distance than Colombia and Chile. We also consider this result interesting and worth exploring further to better understand if power dynamics in engineering classrooms make students have a generally low perception of power distance.

Regarding uncertainty avoidance, we did not find any significant results. Instead, the patterns behaved similarly to what was expected based on the national cultural differences.

Finally, for Masculinity-Femininity, we expected Colombia and Ecuador to have higher scores and Chile and the United States to have the lowest ones; however, all countries ranked very high in our data. Surprisingly, we also had Chile and the United States with higher scores than Colombia. We also consider this dimension worth exploring further as it can be seen that the cultural perception of engineering might impact how students perceive this dimension.

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