

Understanding Cultural Dimensions in Engineering Classrooms: A Scoping Review of the Literature

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Abstract— *Engineering classrooms are becoming increasingly more complex and culturally diverse, presenting new challenges for engineering instructors. Research suggests cultural differences can positively impact learning outcomes, such as enhancing problem-solving and critical thinking skills. However, engineering programs often lack opportunities to integrate educational strategies that enhance students' ability to collaborate across diverse backgrounds and prepare them for the global workforce. This paper examines the application of Hofstede's cultural theory in educational settings and its role in leveraging cultural awareness in engineering classrooms. The study reviewed 225 articles published between January 1983 and July 2025 and identified 76 that met the inclusion criteria. Findings provide an overview of how Hofstede's theory has been employed in education and has positively influenced the study of culture in engineering education. The framework, however, has also encountered criticism from differing epistemological perspectives on culture. The literature supports the utility of Hofstede's theory in understanding social systems, particularly higher education structures, student and faculty behavior, social interactions, and organizational development. To effectively address cultural complexities, academics and administrators must understand cultural dimensions and contextually assess their application, thereby enabling the creation of academic policies and curricula that maximize the advantages of cultural diversity. The growing presence of multicultural students, faculty, and a globalized engineering workforce calls for engineering programs to structure policies and curricula to appreciate cultural differences and equip students for international professional environments.*

Keywords— *Hofstede, culture, cultural dimensions, engineering education.*

I. INTRODUCTION

In an increasingly global educational context, understanding the influence of cultural dimensions on learning environments has become essential, particularly in engineering education, where collaboration and problem-solving are significantly shaped by cultural contexts. Hence, recognizing how cultural values impact classroom dynamics, pedagogical strategies, and student engagement is crucial for fostering effective educational experiences. Within this context, Hofstede's cultural theory provides a valuable framework for educators seeking to examine and adapt their instructional practices.

This paper aims to investigate how Hofstede's cultural theory has been utilized in educational contexts and how educators have leveraged cultural awareness to support and enhance learning in engineering classrooms. By exploring the intersection between cultural dimensions and engineering pedagogy, this study seeks to elucidate both the theoretical

underpinnings and practical implications of employing Hofstede's model.

To build a conceptual base, the paper begins with a review of Hofstede's four original cultural dimensions: Power Distance, Individualism vs. Collectivism, Uncertainty Avoidance, and Masculinity vs. Femininity. These dimensions provide a structured framework for analyzing how cultural norms shape educational expectations, authority relationships, risk tolerance, and gender roles. Each dimension's potential effect on student behavior, instructional design, and classroom interaction is discussed in the context of engineering education.

Next, the paper analyzes Hofstede's model, weighing both support and critique. Though widely adopted, the framework is criticized for methodological limitations, cultural essentialism, and its relevance to changing educational contexts. This section balances the model's strengths and limitations.

Finally, the paper discusses the specific contributions of Hofstede's theory to engineering education. Drawing on empirical studies and pedagogical applications, it highlights how cultural awareness informed by Hofstede's dimensions can enhance curriculum design, foster intercultural competence, and support more effective learning experiences. By synthesizing theoretical insights and practical examples, the paper aims to offer a nuanced understanding of how cultural theory can inform and transform engineering education in multicultural settings.

II. OVERVIEW OF HOFSTEDÉ'S RESEARCH

A. Fuzzi Borders Defining Culture as a Social Construct.

Culture by itself is a notoriously complex topic [1][2][3] with definitions ranging from Edward Burnett Tylor's assertion that culture is a complex social phenomenon (including knowledge, beliefs, morals, law, habits, capabilities, and others social constructs) that is acquired by every person belonging to a society; to definitions of culture as the reflection of the way a certain group of people perceive, appraise, and experience the world [4]. Some authors measure culture as learned behaviors, others as abstractions derived from behaviors, and still others as the relation between selected objects and their meanings to people. Culture exists only in the mind, according to some, so it can only be measured through self-report; according to others, culture can be measured through observation of behaviors and events in the external world [5][6][7]. Hofstede et al. [8] define culture as the way people perceive their values in terms of the desirable and the desired (i.e., beliefs on how the world should be versus what people desire for themselves). The desirable refers to what is right and wrong, acceptable or not by society. On the other hand, desire concerns individuals and the things

they want for themselves. The cultural underpinnings of a society contribute to its stability over time; however, societal norms often diverge from the cultural values determined by the economic and geographical characteristics of different countries [9]. While society establishes norms, policies, and rules about what is perceived as good or desirable, the desired values can be subjective. This subjectivity in the spectrum of values and definitions points to one of the problems of identifying and measuring culture.

B. Culture Through Hofstede's Theoretical Perspective

Hofstede introduced his conceptualization of culture after developing his theory of cultural dimensions in the mid-1960s. In his initial study, he analyzed cultural differences among nations by surveying IBM employees in more than 50 countries about personal values. Hofstede's framework was first published in 1980 in his book *Cultural Consequences: The Dimensions Approach*. Hofstede's initial definition of culture was developed based on his observations of the desired and desirable values of IBM's employees worldwide [10]. He described culture as a "collective programming of the mind," with cultural patterns rooted in the value systems of major groups of individuals that become stabilized over long periods of time as acceptable ways of thinking. His definition of culture has evolved, and in more recent books, Hofstede, Hofstede, and Minkov [11] define culture as patterns of thinking, feeling, and acting that every human being carries. Even more recently, Minkov and Hofstede defined culture as a "system of shared meanings that may be unique to a particular society or a group of societies" (p. 4) [12].

Hofstede's [10] original analysis yielded four dimensions of culture based on problems that are inherent to all societies: (i) social inequality, including the relationship with authority, (ii) the relationship between the individual and the group, (iii) ways of dealing with uncertainty and ambiguity, which turned out to be related to the control of aggression and the expression of emotions, and (iv) 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 [10] labeled his cultural dimensions as power distance (from small to large), individualism (versus collectivism), uncertainty avoidance (from weak to strong), and masculinity (versus femininity).

Hofstede et al. [11] expanded to six dimensions in later studies. The two newer dimensions are not included in this study because they appear to have less bearing on disciplinary culture: long-term/ short-term orientation addresses virtues stemming from teachings of Confucianism, such as "thrift" or "respect for tradition," and indulgence/restraint represents a continuum of how satisfied and happy individuals in a certain nation are with their lives. While these dimensions may be useful delineators of national cultures, the values they address are less relevant to disciplinary contexts because they pertain only to national culture. Hence, this scoping review of the literature is focused on the original four dimensions:

1) *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" (p. 61) [8]. Notably, this dimension addresses inequity as defined and endorsed from below (i.e., the followers rather than the leaders). Exploring disciplines through this dimension can address patterns of student-faculty relationships, preferences for autonomy, communication patterns, and preferred problem types.

2) *Uncertainty avoidance/acceptance* addresses the degree to which members of a culture can operate comfortably with uncertainty. According to Hofstede et al. [11], 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. Exploring disciplines through this dimension can address students' abilities and willingness to collaborate, especially in interdisciplinary teams of unfamiliar territory, as well as their openness to creative problem-solving formulations.

3) *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. In collectivist cultures, people are tightly connected and consolidated into cohesive in-groups with a strong emphasis on group norms and unity [8]. Exploring disciplines through this dimension can address the participation of underrepresented populations in engineering, where collectivist interventions, such as living-learning communities, have proven to be effective social and academic support networks.

4) *Masculinity/femininity* refers to the continuum that represents how emotional roles are distributed across genders, with assertive roles aligned with the masculine pole and caring roles aligned with the feminine pole [11]. Notably, in Hofstede's studies, women show less culture variation than men; they are more assertive and competitive in masculine cultures, but they display similar levels of nurturing in both masculine and feminine cultures. Masculine cultures thus experience a greater gap between men's and women's roles. By exploring disciplines, this dimension can address women's participation in the masculinized culture of engineering going beyond metaphors of "pipes" and "cold weather".

III. METHOD

Influenced by the systematic review procedures proposed by Gough et al. [13], our goal in this scoping review was to identify a representative set of articles that support or critique Hofstede's theory of cultural dimensions, as well as its implementation across different settings. This search was done simultaneously using several databases. Using the search terms: "Hofstede," "cultural dimensions," "culture," and "critique" in any field, the search focused on articles published in peer-

reviewed journals, conference proceedings, and doctoral dissertations between January 1983 and July 2025. We began our review in January 1983, following the publication of Hofstede's first book. Over 42 years of research and studies were analyzed to capture the full extent of Hofstede's theory in practice, up to the point of data saturation. In the initial search, 225 articles were found and analyzed. The final articles were chosen according to these three criteria: (i) the author(s) used Hofstede's theoretical framework in their study, (ii) the author(s) used Hofstede's instrument to understand the cultural differences among their studied populations, and (iii) the author(s) presented theoretical or methodological support for, or a critique of, Hofstede's theory.

Some articles were excluded due to misconceptions of the use of Hofstede's instrument (i.e., using Hofstede's survey to explain accounting principles). Other articles mentioned some of the criteria described in their abstracts; however, in the full paper, there was no evidence of such affirmations, so they were excluded as well. Using this selection process, 76 articles qualified for this study. To mitigate potential initial bias, a rigorous peer-review process was implemented. This process involved five researchers who systematically evaluated the selected articles and provided feedback based on the implementation of Hofstede's theory.

IV. RESULTS

The scoping literature review allowed us to understand the theoretical and empirical literature to examine both sides of the coin. In science, the understanding of reality is based on a mental construction shared by a specific scientific community, and the theory that explains it is not possible to be seen as a unique, absolute, and objective interpretation, instead, epistemological foundations drive the cognitive competences of the social scientists to create theories according to their own mental models, experiences and ways to approach their reality. Hence, even in science, there is space to support or criticize the results of scientific experiences as well as any theoretical frameworks built from them.

Our results provide critiques, recognition, and specific contributions to engineering education regarding one of the most widely used and cited theories that explains the cultural dimensions (i.e., Hofstede) and how it could enhance the benefits of understanding and valuing cultural awareness and differences within engineering classrooms [14].

A. Critiques of Hofstede's Theory.

As part of the scoping review, we identified many critiques to Hofstede's work. Most focus on Hofstede's choices and assumptions in conceptualizing culture. For example, Baskerville, an accounting and finance scholar, argued that culture should be conceptualized within anthropological and sociological traditions and noted that Hofstede's [15] work stems from and is most cited in psychology and management-related disciplines. This approach has led, according to Baskerville, to the flawed assumptions that: (i) a nation can be equated with culture, (ii) culture can be quantified, and (iii) the

observer can be outside the culture. McSweeney [16] also challenged the approach underlying Hofstede's cultural dimensions, critiquing the assumption that IBM's organizational culture does not vary across nations. McSweeney [16] also challenged the assumption that people's behavior in the workplace is representative of other aspects of their lives; rather, they sometimes behave differently in the workplace due to social pressures or organizational culture. Finally, McSweeney [16] argues that Hofstede's cultural dimensions lack contextual considerations and thus lack systematic causation regarding for several reasons: (i) Hofstede does not consider the influence of sub-cultures enough, (ii) he relies on a single explanatory variable to explain cultural causation, leaving out the possible explanations that non-national cultures and the non-cultural could contribute to the behaviors, and (iii) Hofstede assumes that people belonging to a national culture are homogeneous.

Ford et al. state similar objections, that Hofstede's work assumes that culture is static over time, and since the cultural dimensions fall along national boundaries, there is an implicit assumption that national culture is homogeneous (without subcultures) [17]. Similarly, Fang and others [18][19][20] argue that 21st century globalization has given rise to a paradoxical movement of cultures and management practices in which modern people have multicultural identities and multicultural minds beyond their national cultures. According to Fang [21], the perception of cultural learning as extending "longitudinally from one's own ancestors within one's own cultural group" (p. 26) is no longer adequate.

In addition, there is concern that culture evolves over time and Hofstede's perceptions of cultural dimensions should change accordingly [22][23][24]. Several authors propose that the dimensions developed in Hofstede's theory correspond only to the period in which the study was conducted (1960s) and that these dimensions have been incorrectly treated as if they do not change over time [25]. Finally, Hampden-Turner and Trompenaars [26], in line with Baskerville, critique Hofstede's choice to measure culture in mathematical language and in linear exclusive categories. They claim that because culture is dynamic and adaptive, it cannot be accurately quantified using numerical dimensions and matrices. Instead, they argue culture is a qualitative variable and has meanings that depend on the context and external factors [15]. Single elements of the context cannot dictate meaning to explain the whole phenomenon [26].

Hofstede's model has been subject to several methodological critiques, including a lack of internal consistency, replicable dimensions, validity, and finally, problematic wording of the dimensions themselves. Internal Consistency. Several authors have argued that Hofstede's model lacks internal consistency when used to measure cultural differences. To examine the empirical validity of Hofstede's cultural framework, Blodgett et al. [27] conducted an exploratory study that found that, when applied at the individual unit of analysis, the framework lacks reliability and internal consistency.

Similarly, Spector et al. [28] affirm that Hofstede's research does not provide information on internal consistency or reliability of his instrument. The authors conducted a study on 23 of the 40 countries on which Hofstede's theory was based, using his original instrument. Out of 115 Cronbach alpha values calculated, only 13 achieved the 0.7 coefficient that is considered the minimum acceptable alpha, concluding that Hofstede's instrument lacks internal consistency [29].

1) *Replications of the Hofstede's Dimensions.* Other researchers have tried to replicate Hofstede's framework and found that some dimensions do not hold up. Fischer et al. [30] critique the stability of the country-level dimensions in Hofstede's model, arguing that multiple steps in the analysis yielded a large number of lengthy probability sequences that required further cross-validation. Similarly, Smith et al. [31] were unable to replicate the masculinity-femininity and individualism-collectivism dimensions. Chanchani and Theivanathampillai [32] evaluated Hofstede's dimensions in comparison to other cultural typologies and found that Hofstede's model lacked transcendence in its level of analysis, and Smith et al. [31] were unable to replicate the masculinity-femininity and individualism-collectivism dimensions. Similarly, Johnson et al. [33] found that the 4 dimensions were negatively associated with acquiescent response behavior in a study conducted on culture and response styles.

2) *Validity.* Validity in quantitative research refers to the process of accumulating evidence to determine whether a researcher can obtain meaningful information to make useful inferences from data collected, which means that the test is measuring what the instrument is intended to measure [34][35][36]. Moskal et al. [36] suggest that validity is obtained when there is evidence supporting interpretations and the appropriateness of their use.

Validity is the most fundamental consideration in the development of evaluation tests [35]. There are several types of validity critiques that will be discussed in this section: first, face validity, construct validity, and external validity.

To determine the face validity of Hofstede's instrument, Blodgett et al. [37] asked the participants of their study (157 students and faculty members) to map Hofstede's survey questions to the dimensions of culture that he developed. On average, respondents matched the question to the correct dimension only 41.3% of the time. According to the authors, this demonstrated that Hofstede's instrument lacks face validity.

Regarding construct validity, S ndergaard [23] identified several articles that pointed to three major constraints in Hofstede's study: (i) Data collected between 1968 and 1973 are no longer valid, (ii) The use of employees of one company as a basis for conclusions about national dimensions. The proposition that human values are conditioned solely by national culture ignores the potential influence of a variety of other contextual factors; and (iii) The use of attitude surveys alone does not constitute a valid basis for this type of research [38][39].

Chiang [40] raises methodological concerns about the external validity of Hofstede's findings, arguing that generalizability may be compromised by the fact that survey respondents are from a single large multinational corporation (IBM). Fernandez et al. [22] argue that the information collected in their study may be biased by the fact that the sample belonged to a single company. This affirmation is supported by S ndergaard [23], who found that several researchers using Hofstede's model cite this issue as a main weakness. Given that people working in a company tend to develop an organizational culture that may affect their national cultural beliefs, it is possible that employees at IBM worldwide had developed organizational values that affected their responses [41]. The generalizability of the findings is also affected by gender and occupation; in Hofstede's study, mostly male respondents working in marketing and servicing [19].

Finally, Triandis [42] considers the use of a single method of data collection for measurement to be too limiting, especially when analyzing complex concepts such as cultural dimensions. The author suggests using a multi-method research design to obtain reliable information from different sources that can explain the results. This affirmation was accepted and shared by Hofstede himself.

3) *Wording of the Dimensions.* Chiang [40] raises concerns regarding Hofstede's labeling of the dimensions. For example, the term masculinity-femininity has generated some criticism because it may have a sexist tone that is inaccurate and not appropriate, and power-distance can be interpreted, inappropriately, as an indicator of inequality. Adler, cited by Chiang [40], suggested that the power-distance dimension should be relabeled "career success/quality of life" to address this criticism.

4) *Incorrect Application of Hofstede's Dimensions.* Some authors have not criticized Hofstede's theory but its applications, as researchers have attempted to apply a theory of national cultures to the individual level. Brewer and Venaik [43] affirm that the characteristics, scales, and scores of national culture dimensions are often used in research and teaching as if they apply to individuals, when they do not. They highlighted the misapplication of Hofstede's national culture dimensions at the individual level of analysis in both research and teaching. This phenomenon was defined by Piantadosi et al. [44] as the ecological fallacy, i.e., the mistaken assumption that relationships observed for groups will hold for individuals. Items in Hofstede's instrument were highly correlated at the national level, but at the individual level, correlations were very low or nonexistent, and sometimes contradictory [45].

B. Scientific Experiences and Arguments that Support Hofstede's Theory

Hofstede et al. [8] have conducted six major replications of their study in several countries. In addition, many other researchers have also successfully applied the framework in a variety of studies. Hoppe [46] tested the construct validity, obtained data from 1,500 respondents in 19 countries, and used statistical analyses to demonstrate the validity and reliability of

Hofstede's model using a different sample (i.e., managerial, professional, political, and academic elites). Furthermore, on Hofstede's website, there is a country comparison tool which is widely used across the globe. Shane et al. [47] replicated 3 of the 4 dimensions in a study that examined the relationship between national culture and national preferences for innovation championing strategies. They had a sample of 1,228 individuals in 30 countries. The authors confirmed the reliability of Hofstede's scales with Cronbach's alpha, and validity was established by: (i) consulting the instrument with experts in cultural psychology, engineering, and innovation, (ii) using statistical procedures like factor analysis and correlations, and (iii) comparing results of the research with previous results of Hofstede's original work. In another study, Chiang [40] used Hofstede's model to examine how cultural differences can shape the types of rewards employees most desire. However, the author explains that contextual factors may also influence these decisions.

Similarly, Merritt [48] incorporated Hofstede's survey questions into the Flight Management Attitudes Questionnaire (FMAQ) and collected data for 4 years using a sample of 9,417 pilots in 26 airlines in 19 countries. The author replicated Hofstede's study and demonstrated the reliability and validity of his survey. Merritt [48] first conducted pilot testing of the questions, followed by a correlational analysis of the pilots' responses with Hofstede's original country scores for each dimension. A second analysis was conducted by correlating all items in the database, including Hofstede's items, with the new items written for the pilot survey, using Hofstede's index scores. Finally, a cluster analysis was done with the data obtained in the study, which generated clusters that were similar what was expected according to Hofstede's dimensions, demonstrating the validity of Hofstede's model.

De Mooij [49] replicated 3 of the 4 dimensions in a study investigating cultural differences in consumer behaviors. Hofstede's instrument was used in combination with a marketing questionnaire, obtaining results in which three dimensions correlated significantly with the country's scores of Hofstede's initial study and reliability were demonstrated with an internal consistency analysis. In addition, De Mooij [49] conducted a literature review of Hofstede applications, finding that his dimensions are increasingly used as a valid conceptual framework for classifying and explaining the influence of culture on several different research topics outside their original setting.

Another replication of Hofstede's theory was conducted by Mouritzen and Svava [50] in a study of the cultural context of leadership in politicians. They were able to replicate 3 of Hofstede's 4 dimensions and correlated the form of government with Hofstede's index. They also conducted a cluster analysis that allows them to demonstrate the validity of Hofstede's model in a political context. Johnson et al. [33] conducted a study of the 4 dimensions and response styles across cultures in 19 countries. From a dataset of 18,000 questionnaires, they found 2 of the 4 dimensions were positively associated with

extreme response style. Van Nimwegen [51] also replicated Hofstede's study in banking settings and was able to demonstrate validity using a cluster analysis and correlations of his data with Hofstede's original results. Similarly, Ardichvili and Kuchinke [52] used Hofstede's instrument to understand leadership styles and cultural values among managers and subordinates in independent companies in 6 countries. In this study, reliability tests proved internal consistency in the instrument.

Yoo, Donthu, and Lenartowicz [53] successfully developed a scale based on Hofstede's model to measure the dimensions of national culture (individualism, power distance, uncertainty avoidance, and masculinity) at the individual level. The authors modified Hofstede's original instrument and improved it with the support of several experts who were familiar with Hofstede's theory. The improved instrument was piloted and tested with several responses, yielding internal consistency in all four dimensions with ranges of Cronbach's alpha from 0.71 to 0.96. In addition to demonstrating reliability, the authors conducted exploratory and confirmatory factor analyses using data from three separate samples, obtaining results consistent with expectations and establishing construct validity. In addition, validation was established by applying the instrument across three countries and different populations, consistently yielding similar results when performing statistical procedures such as factor analysis.

Brewer and Venaik [43] explain that despite their criticism of Hofstede's theory for ecological fallacy, the model remains valuable for explaining national-level phenomena. Similarly, Grenness [45] affirms that "avoiding the ecological fallacy is possible when the aggregated data are collected from groups or samples which are assumed to be or known to be homogenous, e.g., sharing dominant cultural values" (p. 80). It is necessary to understand the population to be analyzed and to assess homogeneity or heterogeneity to develop methodological solutions for individual behavior based on aggregated data.

Hofstede [54] himself replied to most of the criticism in a reply written to McSweeney [55]. First, he stated that most of the concerns McSweeney raised were addressed in a subsequent edition of *Culture's Consequences* [16]. One of his criticisms was that surveys are not an optimal way to research cultures; Hofstede acknowledges this. He suggests using several methods to obtain trustworthy information regarding culture. He argues that surveys are a valid method for research in the sociological sciences, and when supported by other methods, can yield the results needed to understand complex phenomena such as culture. He also agrees with the concern that nations should not be the unit of analysis for studying cultures, but explains that researchers do not have many options, given that the boundaries of cultures cannot be easily observed or determined. He affirms: "they are (nations) usually the only kind of units available for comparison and better than nothing" (p. 2).

Hofstede [54] also addressed the concern that the data from the IBM study may be obsolete, explaining that the dimensions

have their roots in patterns of behavior that are centuries-old and sociologically consistent over time. He also noted that only data that remained stable across two subsequent surveys were used to develop his theory. He affirms that over the years his instruments have passed multiple test of validity and reliability, in applications both external and internal to his team, over a period of 30 years [56][57][58][59][60][61][62][63][64][65][66][67][68][69][70][71].

A final concern addressed by Hofstede himself was about the development, quality, and quantity of the cultural dimensions. He states that the dimensions are independent in both conceptual and statistical analyses. He affirms that the current dimensions should be validated with external measures of correlations. He is continuously working in the development of new categories and evaluating the validity of the current ones.

C. Hofstede's Theory Contribution to Engineering Education

Research in engineering education has consistently demonstrated that culture significantly shapes how individuals behave, perceive themselves and others, think, solve problems, and interact with their environment [72]. Students in the classroom carry deep-rooted cultural differences that demonstrate in communication styles, perceptions of authority, gender interactions, and preferences for individual versus collaborative work. These differences influence not only psychosocial dynamics but also play a critical role in cognitive processes related to learning, knowledge socialization, and the development of new competencies. This underscores the intricate interplay between cultural, psychosocial, and cognitive dimensions within engineering education.

However, the literature warns that when higher education institutions, particularly undergraduate engineering programs, fail to train academics and researchers with the competencies required to effectively manage cultural diversity, the consequences can be significant [73][74]. These include higher opportunity costs in skill development, greater risks of miscommunication, and an increase in interpersonal conflicts, potentially disrupting the collaborative dynamics essential to academic success [75].

Traditionally, science and engineering curricula have been rigorous and standardized, emphasizing the uniform transmission of knowledge, methods, and tools. This positivist legacy often prioritizes standardization over adaptability, potentially limiting the pedagogical value of cultural diversity as a lens for understanding social and productive systems [73]. Yet, in today's globalized economy, engineers and students must be prepared to operate in highly diverse ecosystems.

Consequently, managing cultural diversity should be a central concern in both curriculum design and engineering pedagogy. This goes beyond fostering intercultural communication between professionals and clients; it involves strengthening collaborative research networks and establishing business relationships among culturally diverse stakeholders.

In this context, Hofstede's cultural dimensions theory provides valuable insights into dimensions such as individualism–collectivism, masculinity–femininity,

uncertainty avoidance, and power distance. These dimensions shape cognitive frameworks that, in turn, influence classroom behavior and, by extension, future professional practices. The scoping review of the literature identified guided group work or teamwork as the most effective pedagogical strategy for leveraging cultural awareness in engineering classrooms. This approach not only supports academic achievement but also promotes culturally sensitive behavior and fosters constructive interpersonal relationships in both personal and professional settings [73].

Stryker and Stryker [72] state that interaction among culturally diverse students promotes innovation and creativity in problem-solving, while collaborative work encourages divergent thinking. Therefore, it is essential for engineering educators to encourage open, effective, and psychologically safe communication, positioning the classroom as a supportive environment where cultural awareness becomes a source of learning and growth.

Another noteworthy aspect highlighted in the review is the holistic vision that university administrators must adopt. An organizational culture should be established with the capacity to fully take advantage of cultural diversity and awareness as social factors that enhance institutional productivity and quality, rather than perceiving it as a problematic or insignificant issue. This is not an exclusive task of university academics; it is a commitment that must be embraced institutionally to become an integral part of the organizational culture.

Walden, Trytten, and Shehab [76] propose that it is essential to develop a network of interconnected actions to understand and manage the advantages of cultural awareness within engineering programs, emphasizing the need to address the following three dimensions:

- 1) *Interpersonal and organizational communication.* Students bring with them a variety of prior knowledge, habits, learning styles, and culturally diverse social norms, as well as different ways of interacting and perceiving interpersonal relationships. Therefore, engineering programs must continually strive to understand how their students communicate, the main barriers to communication, and the advantages and disadvantages of the communication channels they frequently use. Faculty, staff, and students within engineering colleges must develop the ability to manage communication effectively and productively amid cultural differences.

- 2) *Organizational and college culture.* Culture is understood as the set of shared social elements, including values, assumptions, beliefs, attitudes, ideologies, and rituals. Institutions should explicitly recognize in their policies and procedures both the importance and the respect for cultural awareness. Such declarations lay the foundation for individuals to adjust their behavior toward greater appreciation of cultural differences, thus fostering a proactive academic culture [77]. Moreover, assessing the implementation of these policies and procedures in engineering colleges is crucial—not only to

evaluate their impact but also to reformulate them as needed and deepen the achievement of new standards.

3) *Classroom culture and social interaction between faculty and students.* Academics must be competent at identifying cultural differences and applying strategies that promote a healthy, productive learning environment in engineering classrooms [78]. Educational institutions should encourage academics, staff, and students to develop competencies for managing cultural awareness [74]. Educators should also promote transformational leadership and teamwork, as these provide productive opportunities for students to learn how to collaborate and coexist within cultural differences as part of their engineering education [79][8]. Meaningful learning about cultural values can therefore emerge through collaborative project development and academic mentorship.

Integrating Hofstede's cultural dimensions into engineering education provides a valuable framework for understanding how cultural values influence teaching, learning, and collaboration within academic contexts. Recognizing the impact of dimensions such as power distance, individualism versus collectivism, uncertainty avoidance, and long-term orientation allows institutions to design more effective and culturally responsive educational environments. By acknowledging these cultural differences, engineering programs can foster more effective communication, enhance teamwork, and encourage critical thinking in students. Ultimately, incorporating intercultural awareness grounded in Hofstede's model strengthens the preparation of engineering students to operate successfully in an increasingly globalized and culturally interconnected professional landscape.

V. DISCUSSION

Based on these studies, it is possible to argue that Hofstede's dimensions can be helpful to understand cultural differences and contextualizing culture in academic classrooms. His four dimensions are constructs that respond to social issues shared by almost every person belonging to any type of culture [8][81], and these constructs can be useful not only to understand disciplinary engineering culture but also to help educators understand how those cultural differences can connect to their pedagogical practices to make sure cultural differences are valued in the classroom.

In terms of the four dimensions, the dimension of Individualism is particularly important to understand disciplinary culture in engineering majors because there is a demand for engineers to be able to work collaboratively in teams, and to solve problems with people who have different perspectives [82][83][84]. Uncertainty avoidance can provide valuable insights into how engineering students feel about thinking outside the box, changing rules, and working with other disciplines they are unfamiliar with. Power distance can provide information regarding student and faculty member interactions and relationships, preferences for autonomy, communication patterns, and the role of the follower (student) and the leader (instructor) in the discipline. Masculinity is also

very important for the understanding of disciplinary cultures in engineering majors because it may provide information that helps change the masculine perception of the engineering field. It can also provide information to improve inclusion and diversity, and to make engineering schools more welcoming.

Hofstede's model also allows for understanding disciplinary cultures among engineering students based on their individual perceptions of their values and behaviors beyond the classroom. Hofstede et al. [8] affirm: "values, more than practices, are the stable element in culture, comparative research on culture starts from the measurement of values" (p. 28). Most of the previously discussed models that address differences in academic or disciplinary cultures describe accepted practices within the discipline rather than the values shared by members of academic units.

The survey questions linked to Hofstede's constructs ask participants to think about how they respond to situations and what they value. In engineering majors, for example, different academic departments with very similar curricula and course structures can perform very differently because of the varying perceptions that members of the department may hold regarding their disciplinary culture [85]. Hofstede's dimensions can provide information on how students may be similar or different in how they behave in their disciplines, in terms of culture, using constructs that are not directly related to academic settings (i.e., individualism, power distance, uncertainty avoidance, and masculinity).

Similarly, Hofstede's theory can provide insights into how engineering majors can work more effectively not only with other engineering majors but also with collaborators from other disciplines. Hofstede's theory can be valuable in overcoming the main issues proposed by Bradbeer [86] as barriers to interdisciplinarity: (i) differences in disciplinary epistemology, (ii) differences in disciplinary discourses, (iii) differences in disciplinary traditions of teaching and learning, and (iv) differences in students' preferred learning approaches and styles. Understanding Hofstede's dimensions of disciplinary culture in engineering majors will help faculty members develop diverse teaching strategies to accommodate different learning styles and provide students with information to help them become self-aware learners.

VI. CONCLUSION

Results from the scoping review suggest that Hofstede's theory has been used in multiple ways for more than 40 years. The framework influenced how culture is studied, including in academic disciplines. However, the framework has received some criticism. The main critiques stemmed from the differing epistemological views of culture, positivist, and interpretative paradigms. Culture is a complex social phenomenon that is extremely difficult to measure; some of the criticism has focused on the use of a theory developed to identify cultural differences, being applied in contexts beyond the national culture. Most of the studies, nevertheless, support the validity of Hofstede's theory to understand (i) social systems, in

particular the higher education system, (ii) students and instructors' behavior, (iii) people's social interactions, and even (iv) why and how organizational structures are developed. Out of the different constructs of Hofstede's theory, it was possible to identify collectivism and power distance as the most effective ones to understand various aspects of undergraduate classrooms. In the context of engineering programs, where innovation and problem-solving are critical competencies, the review highlighted that instructors lack preparation to address cultural issues and leverage cultural differences in the classroom, particularly in cultural studies. Studies describe that engineering students perceive cultural issues as a productive resource in their undergraduate studies; sharing different experiences and backgrounds prepares them for increasing global participation in a multicultural workforce. Several studies have shown that uncertainty avoidance and masculinity/femininity (two other constructs in Hofstede's theory) can explain variations in learning behaviors across learning contexts. Nevertheless, the engineering workforce is demanding stronger social competencies, as leadership and teamwork are built into the engineering curriculum. To understand cultural issues, academics and administrators must grasp cultural dimensions and assess their contexts to better understand their traits, enabling them to develop effective academic policies and curricula that leverage the advantages of cultural aspects and differences.

Hofstede's theory of cultural dimensions is a valuable framework for understanding cultural differences, and the entire education system within engineering programs is no exception. The increased participation of multicultural students, academics, and a globalized engineering workforce is demanding that engineering programs encourage their academic policies and curriculum to understand and value cultural differences and prepare students for a globalized world. The Hofstede framework has been used effectively for years to understand and implement practical approaches to managing cultural differences across classrooms and academic programs, making it a helpful framework to consider.

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