WIP: Exploration of Conceptions and Attitudes of Colombian and American Chemical Engineers about Chemical Engineering

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Abstract

Background and Purpose: As a Work In Progress (WIP) study, we expect to identify and compare the conceptions and attitudes of undergraduate and graduate chemical engineers about engineering and technology, based on Colombian and American sociocultural and historical identities. In Colombia, chemical engineers’ perception of themselves and engineering is related to the utility that this profession has for the economic development of the country and for solving industrial challenges and problems. It seems that this perception is very appreciated for this community and for the universities which teach this discipline because these are abilities for securing a job. Nevertheless, this perception of engineering seems to be different from the idea that American chemical engineers consider, where, in addition to the previous conception, this agent is closer to normal science investigations.

Methodology: A mixed survey questionnaire will be applied to undergraduate and graduate Colombian and American chemical engineers. For deeper information, a semi-structured interview will be done to a smaller population, based on the results of the quantitative moment. Responses will be analyzed employing a genetic-structural convergence approach about attitudes and conceptions.

Findings and Conclusions: We expect to recognize the difference between Colombian and American undergraduate and graduate attitudes about engineering related to the socio-historical construction, use and actions around this concept.

Implications: To compare with other countries, the conceptions and attitudes about chemical engineering and chemical engineering technology contribute to making visible the differences and similarities between these concepts related to the sociocultural and historical approach. Additionally, it is an opportunity to set up undergraduate curriculums and policies about engineering education taking into account the context in which they are developed.

Background and Purpose

The biggest challenge that diverse educational institutions have in Colombia is to build curricula which include the experience, knowledge, beliefs, and attitudes of different actors. Higher education institutions should not be outside to these characteristics because they allow more meaningful learning [1], the construction of critical thinking in students inside practice communities [2], and the transcendence of content and competencies to the real world outside the classroom. However, this idea of what a professional must be is hidden by three structural problems which constitute the predominant traditional curricula: Homogenization of the population, partialization of knowledge [3], and privilege learning by content and not skill development [4].

In Colombia, Chemical Engineering is characterized by traditional teaching, where an expert – most of the time the holder of a Chemical Engineering degree- suggests the content that students should learn, and the professional profile those must have, based in the market. Clearly, these parts of the construction of the curricula impact the perception that chemical engineers have about themselves as part of this discipline, their relation with other disciplines and the real world.
In this way, a chemical engineer's perception of what it means to be an engineer seems to be related to the abilities this profession brings to solving daily challenges and problems proposed by the industry, as well as to boosting the economic development of the country. In this sense, this conception of a chemical engineer is very appreciated in Colombia by this community and the different universities which form in these essential abilities according to the definition of chemical engineering proposed by the Colombian Ministry of Education [5]. Nevertheless, these perceptions seem to be different from the sociocultural conceptions and attitudes that chemical engineers from the United States consider in terms of being a professional of this discipline. In the United States, being a chemical engineer has two possibilities: The first one, related to a profession close to normal science research in his discipline, as proposed by Kuhn [6], and the second one related to the application of this knowledge in the industry –also called chemical engineering technology.

In this order of ideas, this Work In Progress (WIP) paper seeks to answer the research question: What and how are the attitudes of undergraduate and graduate chemical engineers from Colombia and the United States related to chemical engineering and chemical engineering technology? In this way, comparing the conceptions and attitudes about Chemical Engineering of two different cultures contributes to making visible the differences and similarities between them, being an opportunity to establish undergraduate curricula and policies on engineering education that are contextualized to the environment and provide a voice to the students. Therefore, we take as an epistemological framework the pragmatic paradigm trying to converge genetic and structural social representations’ approaches as a mediating element of the relationships between the attitudes and as a mechanism for analyzing the information collected [7].

**Theoretical framework**

In this way, it is interesting to identify and compare how these professionals conceive and act on chemical engineering, from their different sociocultural and historical frameworks they have naturally appropriated in their countries. To accomplish this, the study will use the tension between Social Representations (SR) and Attitudes and their viable solution, as a framework for the development of the objectives. First, social representations, focused from a sociological perspective, refer to the way a group of people perceives a particular phenomenon from their sociocultural knowledge learned throughout life [8]. They also respond to phenomena of core and periphery, in which the meanings that the community offers to the phenomenon are developed and consolidated. According to Abric [9], in the nucleus would be found the attitudes that the community manifests towards the phenomenon, while the periphery is considered as the interaction space between SR through the values. On the other hand, the attitudes respond to a mentalist approach which correlates with the SR from its origins and was changing over time to complete differentiation as a mental and individual phenomenon that pre-defines the behavior of the individual from the assessment. For mediating this conflict, Parales-Quenza propose to consider these approaches from a genetic-structural perspective which conciliates these paradigms through the conversion of the horizon of attitudes towards peripheral components of the SR, releasing the tension existing between them [10] (Fig. 1).
Methodology

We used a mixed research design based on pragmatism, which allows the search for meaning of the phenomena investigated through the combination of quantitative and qualitative approaches, the intersubjectivity in the capacity to the researcher, without falling into the extremes of complete objectivity or complete subjectivity, and the consideration that there is both a particular real world and diverse individual interpretations of that world [11]. Likewise, this paradigm assumes the transferability of the theories and methods from one research to another as a practical way of explaining the phenomena studied in any of the moments of the research process, addressing both the particular context of each case and the generalization and mobilization between them. On the other hand, this paradigm does not presuppose contradictions about ontological or epistemological assumptions since it is more important to respond to the situation from an empirical perspective [12].

The methodological design of any research proposal must be intimately related to the paradigm and approaches, perspectives or appropriate positions by the researcher. In this way, the use of a mixed investigation entails a design that integrates quantitative and qualitative methods in some or all of the parts of the process. Specifically, for the research project, we make a sequential explanatory design of quantitative predominance and importance, which responses to the research question designed [13]. Additionally, we conduct this study through a predominantly deductive theoretical way, since this type of design incorporates a quantitative nuclear component, followed by a qualitative sequential component. With this, we consider the possibility of moving from the world of the general (hypothesis/theories) to the particular world [14], also trying to refute the hypothesis: The attitudes and conceptions of Colombian chemical engineers are inconsistent with the attitudes and conceptions of American chemical engineers, in relation to technology and engineering.
Also, according to the arguments given from the paradigm and the type of design proposed, our role as researchers vary in each of the moments of the project due to the changes that occur between the quantitative and qualitative designs [15]. So, as a first objective, this paper will approach the question from an expert position that controls subjectivity and knows the theory and context in which the surveys will be applied. In this way, to mitigate context errors, we will validate the evaluation instruments (one in Spanish and the other one in English) through a pilot test with three chemical engineers in each case. In the qualitative phase moment, the investigators’ role will change to that of a researcher who values objectivity and relates it to previously found information in order to have a broad picture of what engineering and technology mean in different two socio-historical contexts.

Population

The present research will be carried out with chemical engineering students and chemical engineers graduates or resident in Colombia and the United States. In both countries, the sample will be taken using social media and targeted online snowball sampling, because this is a Hard-to-reach population and due to the limited amount of available economic resources for collecting information in both countries [16]. For this reason, in the first phase the initial participants will be taken from virtual social networks of Colombian and United Statesian chemical engineers. In the qualitative phase there will be interviewed three chemical engineers in each country who correspond to outlier’s data after the statistical analysis of quantitative phase.

Collection and analysis

The development of each research moment is influenced by the methodological decisions (sequential explanatory design) and theoretical decisions previously described [13]. For the present WIP, the methodological explanation is related to quantitative, qualitative, and mixing phases.

1. Quantitative phase
   a. Selection of the participants: Sample of convenience [17] by snowball beginning with some chemical engineers from undergraduate and graduate chemical engineer’s virtual social networks who want to answer and reference the survey by online (quantitative).
   b. Collection of information: Through a validated survey by an expert review and a pilot test of the instrument [18] containing closed multiple choice questions (quantitative) and open list free questions (qualitative). The online survey was structured using and adapting some questions from Academic Pathways of People Learning Engineering Survey (APPLES), Pittsburgh Freshman Engineering Attitudes Survey (PFEAS) and Senior Undergraduate Survey (EC2000). Also, there were created some own elaboration questions for deepening in the information. This part of the process is going to be done in April and May 2018.
   c. Analysis of the information: We will use descriptive and inferential statistics to analyze the closed questions (quantitative) using Microsoft Excel and SPSS v. 24. Regarding the open questions, we will analyze frequencies and association nodes, quantifying the results obtained [19] through Gephi v. 0.9.2. and data mining software Weka v. 3.8.1.

2. Qualitative phase.
   a. Selection of the participants: Of the people surveyed, those 3 people per country that
voluntarily want to be part of this moment, will be interviewed once the analysis of the quantitative information has been carried out. Preferably, we will seek contact with people who have had answers outside the statistical parameters considered as normal or with those who wish to contribute to the deepening of the information found (intentional sampling) [16].

b. Collection of information: Interviews with open questions (qualitative) in order to deepen, particularize and provide meaning to what was found in the information collected at the quantitative moment [12]. It should be noted that the information will be collected in accordance with the data protection laws that each country handles.

c. Analysis of the information: The information collected will be done through NVivo v. Software. 11.4.0 in order to organize, analyze and find relationships and categories in the qualitative data as well as to quantify the information [18]. In this way, the validity of the analysis and the transferability of the information is guaranteed once the moment of integration of the information is done.

3. **Mixing phase (Data integration)**

This phase will be at the moment of interpretation of the data after the collection and the individual analysis of the quantitative and qualitative data. In some cases, the information could be combined according to how they respond to the resolution of the research question [12]. Operationally, this integration will be given at the beginning by countries, to then make a comparison of the results -through tables and graphs- between these two territories since the questions of the questionnaire and the interview will be the same for both. In this way, it will be possible to answer the question and hypotheses proposed, according to how attitudes and conceptions are shaped in each population and in chemical engineers in general.

**Anticipated Results and Findings**

First, we expect to characterize socio-demographically the students and chemical engineers graduated from diverse regions of each of the countries. Second, we assume that there will be different conceptions about chemical engineering and chemical engineering technology in Colombian and American participants, in relation to the socio-demographic information. Thus, we should consider that the attitudes and conceptions about these concepts were related, in the United States, as the idea that chemical engineer is the person who theorizes about this discipline and chemical engineering technologist is the person who applies the theory in the industry field, meanwhile in Colombia a chemical engineer is who applies chemical engineering theory in the industry field and chemical engineering technologist is the person who assists the chemical engineer. Also, we hope to find a relation between the definition proposed by the legal (laws) or institutional (curricula) conception of these concepts with the found results.

**References**