

AC 2010-347: ELICITING P-12 MEXICAN TEACHERS' IMAGES OF ENGINEERING: WHAT DO ENGINEERS DO?

Silvia Carreño, Universidad de las Americas Puebla

Silvia Carreño is Science, Engineering, and Technology Education Ph.D. Student at Universidad de las Americas Puebla in Mexico. She teaches English related courses. Her research interests include women in science and engineering, and creating effective learning environments.

Enrique Palou, Universidad de las Americas, Puebla

Enrique Palou is Director, Center for Science, Engineering, and Technology Education; and Professor, Department of Chemical and Food Engineering at Universidad de las Americas Puebla in Mexico. He teaches engineering, food science, and education related courses. His research interests include emerging technologies for food processing, creating effective learning environments, and building rigorous research capacity in science, engineering and technology education.

Aurelio López-Malo, Universidad de las Americas, Puebla

Aurelio Lopez-Malo is Professor and Chair, Department of Chemical and Food Engineering at Universidad de las Americas Puebla in Mexico. He teaches food science and engineering related courses. His research interests include emerging technologies for food processing, natural antimicrobials, and active learning.

Eliciting P-12 Mexican Teachers' Images of Engineering: What Do Engineers Do?

Abstract

This study collected data using a modified *Draw an Engineer* (DAE) test followed up by unstructured informal interviews. The 134 Mexican teachers participating in the study were given the DAE test at the beginning of an unrelated workshop. The purpose of the DAE test was to determine individual conceptions of engineers and engineering. Analysis of the teachers' drawings and answers to question prompts indicated the emergence of three main categories: 1) Engineers in action, 2) Occurrence of gender, and 3) Engineering tools. Drawings recorded as Repairing-Building represent 22% and portrayed mainly engineers working on a construction site. Further, 83% of the drawings were recorded as Designing-Supervising-Experimenting, depicting individuals who are mainly supervising others work. Even though the female participants (107) in this program were almost four times the number of male participants, the majority (72%) of the drawings depicted a male engineer at work. The DAE test appears to be an appropriate tool to elicit perception of the engineering profession among Mexican teachers. Analysis of constructed responses indicates that most teachers held common misconceptions about engineers while very few were knowledgeable about what engineers do.

Introduction

The Mexican public has an incomplete understanding of engineers and engineering as a profession^{11, 14}. In discussions about the public's understanding of engineers, many reference the "conventional" stereotype of engineers as construction workers or individuals who repair mechanical and/or electronic apparatus¹¹. Though this stereotype may exist among teachers and students as well as the public, few investigations to date have focused on Mexican teachers' ideas about engineers and engineering. Additionally, most P-12 Mexican teachers and students never get the chance to learn about engineering^{1, 15}. Something similar happens in the United States where P-12 teachers typically do not have adequate access to or knowledge about engineering, which limits their ability to bring engineering into their classrooms^{3, 8}.

Teachers' attitudes towards science affect their students' attitudes towards science¹⁷. This means teachers' perceptions of and attitudes toward engineers and engineering can play a significant role in perpetuating perceptions and stereotypes. The purpose of this study was to better understand how P-12 Mexican teachers conceive the concept of engineers and engineering as a profession, because these teachers will be the ones that integrate engineering into their curriculums and deliver messages about the nature of engineering to their students⁸. Further, beliefs regarding appropriate roles for males and females are as pervasive in our society as they are subtle. Engineering fields are no exception to the assigning of these stereotypic roles. There is evidence that the inculcation of gender stereotypes begins at a young age and that young students quickly learn which fields are "appropriate" for them¹³. Obviously, the "problem" of women in engineering is not simply one of recruitment. The "leaky pipeline" remains a major

issue, as women entrants are lost disproportionately and often get overtaken by men peers in their careers⁴.

Images shape the way individuals view the world³, thus, eliciting and understanding the image Mexican teachers have of engineers and engineering is extremely important in order to develop programs and curricula that encourage engineering learning at the P-12 school levels. Subject-produced drawings offer a simple and unique way for researchers to assess individual conceptions. These individual-produced drawings offer a window into human sense making that is often beyond description using mere words⁵. Psychologists, scientists, sociologists, anthropologists, and education researchers, among others have used and continue to use subject-produced drawings in their research. In the 1950s, the famous anthropologist, Margaret Mead, asked US students to draw pictures of scientists¹⁰. The “Draw a Scientist (DAS) test” has been widely used to assess students’ attitudes about scientists², even with Mexican students¹⁴. To help assess students’ ideas about engineering a “Draw an Engineer (DAE) test” was developed^{7, 9, 16} derived from the DAS test.

Methods

For over 10 years, professors from our university, *Universidad de las Américas Puebla* (UDLAP), have been working with the company *Calizas Industriales del Carmen* (CALICA) on a community service project whose main objective is to provide teacher development programs at an annual regional conference (sponsored by CALICA) in the Mexican state of Quintana Roo. These programs involve offering for 3 days, distinguished lectures, seminars, and workshops at no cost to teachers in attendance. The program designed for each conference is always different and includes recent educational developments. Workshops offer practical tools to the teachers in order to help them enhance their daily teaching activities, and different areas have been covered including math, history, Spanish, foreign languages, literature, science, and engineering, among others¹².

This study collected data using a modified DAE test⁵ followed up by unstructured informal interviews. The 134 teachers participating in the study were given the DAE test at the beginning of an unrelated workshop during the 2009 Quintana Roo regional conference. The purpose of the DAE test was to determine individual conceptions of engineers and engineering. Gender detailed information regarding the demographic status of the teachers’ population is presented in Table 1. Approximately 43% of the teachers were from elementary school (grades 1-6 in Mexico), 26% from middle school (grades 7-9 in Mexico), 17% from preschool and kindergarten, 6% from high school (grades 10-12 in Mexico), while the rest are principals in their schools.

Table 1. Participants by Gender

Gender	Number	Percent
Male	27	20.1%
Female	107	79.9%
Total	134	100%

Regarding attendees' years of experience, 20% of them have taught for less than 5 years, 20% for more than 20 years, 23% of them have between 5 and 10 years of experience, while 25% of them have between 10 and 15 years of experience.

Teachers were given 10 min to draw an engineer (previously they were asked to close their eyes and imagine an engineer at work) on a sheet of paper (directions were read to the teachers and also provided in writing in the sheet of paper). Once they had completed their drawings, teachers were given 15 min to answer three question prompts (read by a facilitator and projected on the screen for the whole audience to see them during the entire 15 min) related to what they had drawn: 1) Describe what the engineer is doing in your drawing. Write at least two sentences. 2) List at least three words/phrases that come to mind when you think of an engineer. 3) What kinds of things do you think an engineer does on a typical day? List at least three things. Workshop facilitators were careful not to talk about engineers or engineering during the administration of the DAE test. During the DAE administration, project coordinators offered help to clarify directions and question prompts, but they did not offer any ideas or assistance that would influence the teachers' original conceptions of engineers or engineering. Twenty informal interviews (which were videotaped) were performed during the DAE test and consisted of one-on-one discussions between a facilitator and a teacher to investigate reasoning's behind his/her drawing and responses.

Data from the DAE test were analyzed by identifying qualitatively distinct categories or clusters. Three researchers were involved in the analysis process. The analysis process began with open coding because there were no pre-determined categories⁵. Analysis of the teacher's drawings and answers to question prompts indicated the emergence of three main categories: 1) Engineers in action, 2) Occurrence of gender, and 3) Engineering tools. Key elements that depicted engineers in action included drawings of engineers building, repairing, designing, supervising, and experimenting. Thus, building and repairing were combined into one component while designing, supervising, and experimenting were combined into a second component.

Results and Discussion

In this section we will use the term *drawing* to represent a teacher's drawing and question responses. Drawings recorded as Repairing-Building represent 22% and portrayed mainly engineers working on a construction site. Further, 83% of the drawings were recorded as Designing-Supervising-Experimenting, depicting individuals who are mainly supervising others work (Figure 1). Even though the female participants (107) in this program were almost four times the number of male participants, the majority (72%) of the drawings depicted a male engineer at work, while only six teachers included a male and a female or a neutral figure in their drawing (Figure 2). Engineering tools corresponded to the activity depicted in the pictures and included specific tools, equipment, and clothing. The informal interviews corroborated major findings while helping researchers gain insight into individual reasoning behind these interviewed teachers' drawings.

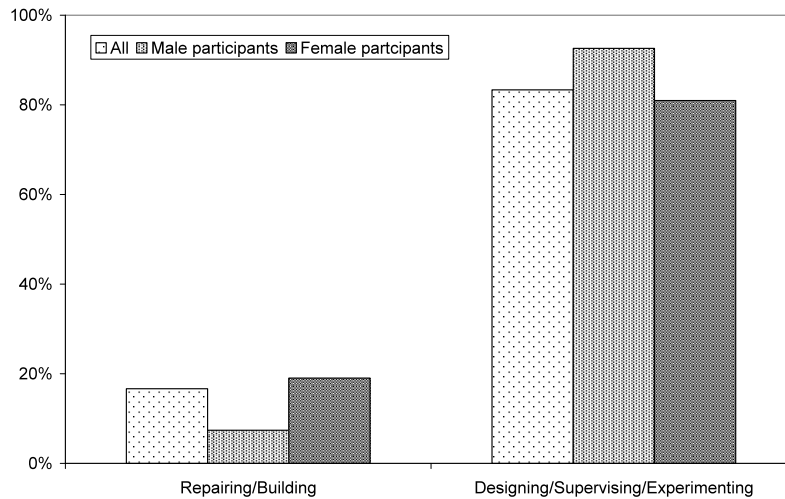


Figure 1. Distribution of images in participants' drawings of engineers

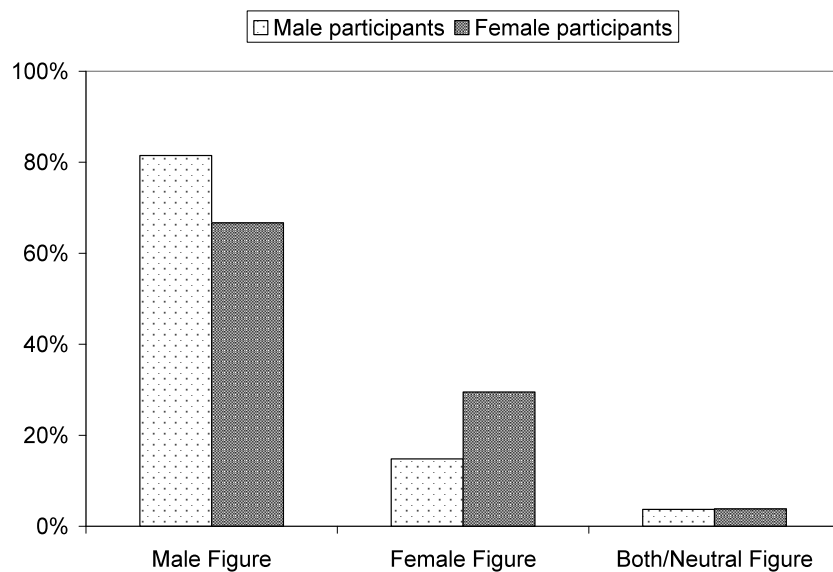


Figure 2. Occurrences of gender among male and female participants.

Engineers in drawings were also characterized by other attributes. The most preferred tools for women and men were helmets, blueprints, drafts, cranes, and shovels, as well as a laboratory material, lab coats, glasses & goggles, in these particular drawings were depicted female engineers doing some research. The most common activities related to engineering were supervising, designing, and directing a construction, process or people; teachers draw different activities and tools including some engineers experimenting. Only 18% of teachers selected as an engineering activity repairing or building. A lot of figures seemed to show an image of an engineer focusing on the mental aspects of engineering.

Figure 3 exhibits that teachers portray engineers mainly as an individual directing or supervising people who are operating civil engineering structures, building tools and vehicles. At the same time, some of the drawings depicted engineers leading an experiment (a women chemical engineer in Figure 3). In Figure 4, the things engineers are doing involve primarily building, (repairing) and designing. The fact that so many teachers portrayed engineers with high level of mental functions (explaining, experimenting) is very interesting. It reveals that many Mexican teachers' perceived an engineer more as a "thinker" rather than a "doer" which represents a lack of perception instead of an inaccurate perception.

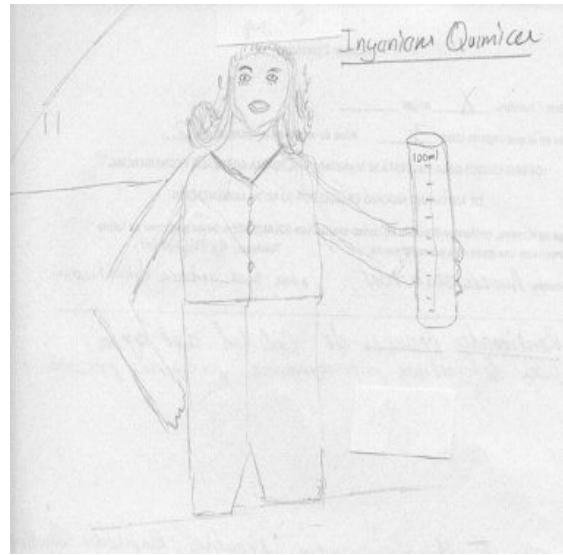


Figure 3. Drawing examples of an engineer supervising (left) and experimenting (right).

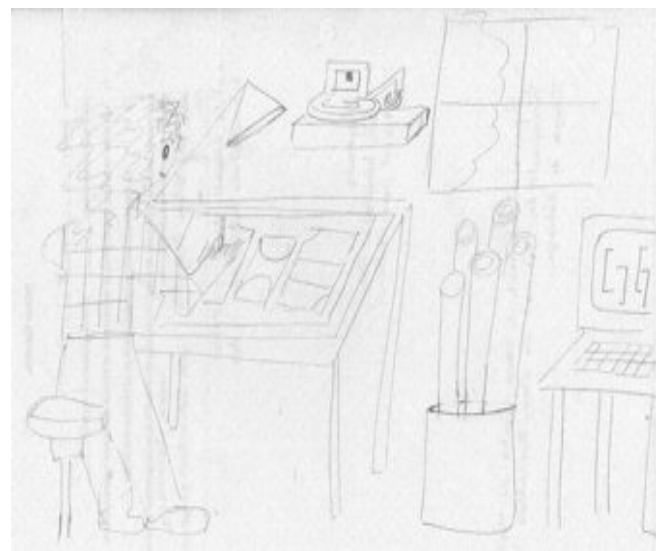


Figure 4. Drawing examples of an engineer building (left) and designing (right).

For the “directing” interpretation is seemed that the clothing revealed the teachers’ perceptions of this field and those who work in them. Several Mexican teachers depicted a high percentage of engineers wearing a suit and tie, many also draw lab coat clothing and just a few of the drawings showed blue-collar clothing. Drawings of “directing” engineers also present a high number of notebooks, math symbols, signs of thinking, etc.

Box 1. Selected examples of accurate perceptions from teachers

- She is carrying some blueprints to show her colleagues the projects that she has planned, since these blueprints are a lot, a friend comes down to help her.
 - o *Está llevando los planos para mostrarle a sus compañeros los proyectos que tiene planeados, como son bastantes un amigo baja a ayudarla.*
- The engineer is responsible for the control of the plastic products production machinery. She has to pay special attention to the quantity of raw materials, size of the product, and operation of the equipment
 - o *La ingeniero está encargada del control de la maquinaria de producción de productos de plástico. Tiene que estar atenta a la cantidad de materia prima, tamaño del producto y funcionamiento de la maquinaria*
- He is supervising the construction work of a school, he is comparing his notes to the work that has been done by the workers and he is indicating how to perform the work
 - o *Supervisando los trabajos de la construcción de una escuela, comparando sus apuntes con lo que hacen los trabajadores e indicando como hacer las cosas.*
- The engineer is coordinating the work and he is watching that the work is being carried out according to what was planned
 - o *El ingeniero está coordinando el trabajo y está vigilando que se realice según lo planeado*
- The engineer is collecting rubble of the construction
 - o *El ingeniero está recogiendo escombros de una obra*
- The engineer is admiring the structure and design that he carried out. He is appreciating the use being given to the bridge that he designed and built
 - o *El ingeniero está apreciando la estructura y diseño que realizó. Aprecia el uso que se le está dando al puente que diseñó y construyó*
- She is running some quality tests for the water, in order to determine if there are pathogenic microorganisms in it.
 - o *Ella está realizando pruebas de calidad del agua para determinar microorganismos patógenos presentes.*
- Directing a construction, verifying that all the workers are carrying out their function and supervising.
 - o *Dirigiendo una construcción, verificando que todos los trabajadores estén realizando su función y supervisando*

Very few teachers have accurate perceptions of engineering, their answers to the question “Describe what the engineer is doing in the picture” probe an accurate knowledge about what and engineer does as can be seen in Box 1. However, most of them are far from actually depict

an engineer in action. This means that if P-12 Mexican teachers' perceptions of and attitudes toward engineering are not accurate, they will play a significant role in perpetuating incorrect perceptions about engineering⁸. This will be reflected into their curricula and in the way they deliver messages about the nature of engineering to their students. Teachers' perceptions matter, they influence attitudes toward, and a willingness to engage in engineering related activities⁹. Ultimately perceptions could affect students' career options, contributing to the significant mismatch between the demographics of the engineering work force and the demographics of the general population in Mexico. The first step towards increasing participation in, and developing a greater understanding of engineering disciplines is to inform P-12 students about engineering disciplines and reduce inaccurate perceptions related to these fields⁸.

Further, Mexican women teachers have to work on their stereotypes about gender-related professions, because most of their drawing were related to a men figure, that means that most of women teachers believe that women should not pursue engineering as a career choice. Understanding teachers' ideas about engineering may give some clues⁷ as to why not so many students, especially female students, elect to go into engineering majors in Mexico.

Mexican teachers' poorly developed concepts are for sure not limited to engineering. They need to develop better understandings of other phenomena and occupations to better understand engineering⁶. This study gave us more clues of what the other fields are and how to overcome this problem. Our findings showed, for example, that several teachers confused engineering with architecture and engineers with construction workers and blue-collar labor. To improve these teachers' views of engineering and the nature of engineering, they should be taught by comparing engineering with these fields. Without enriching Mexican teachers' conceptions of other fields, including architecture, efforts to improve teachers' views of engineering may be relatively unsuccessful⁶.

Final Remarks

The DAE test appears to be an appropriate tool to elicit perception of the engineering profession among Mexican teachers. Analysis of constructed responses indicates that most teachers held common misconceptions about engineers while very few were knowledgeable about what engineers do. By taking these misconceptions into account, intervention and outreach programs can directly address these ideas, and engage teachers in discussions in order to form more accurate understandings of the role of the engineer and the engineering profession.

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