



Recruiting More US Women into Engineering Based on Stories from Morocco

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Introduction

The objective of this project is to examine the differences between Moroccan and American cultures with regards to prevalent messaging about engineering. This examination will help us determine the factors that contribute to women's decisions to pursue engineering degrees at higher rates in Morocco and similar non-western cultures. Due to a partnership between our university and the International University of Rabat in Morocco, engineering students have been completing their masters of science degrees in aerospace or mechanical engineering. We launched our study to determine the impact of culture on career choice when we noted that almost equal numbers of Moroccan men and women arrived at our university each year since 2015. This work is an exploratory qualitative case study that uses the combined frameworks of Hofstede's Cultural Dimension Theory and Eccles' Expectancy-Value Theory.

According to a report entitled "Is U.S. Science and Technology Adrift?" released by the Commission on Professionals in Science and Technology (CPST), the United States' engineering workforce is growing but still lagging behind the overall growth of the country [1]. The U.S. World News/ Raytheon STEM report shows that the U.S. continues to have a shortage of STEM workers and, furthermore, that the increase in 2016 STEM degrees was primarily awarded to foreigners with temporary visas [2]. These findings indicate that the U.S. will rely on foreign workers to fill future STEM jobs. One way to address this shortage is increased participation in engineering of minorities and other underrepresented groups. Therefore, the goal of this study is to generate knowledge from a different culture, which can be used to increase the number of American women pursuing careers in engineering fields to meet the U.S. workforce needs.

Although a few studies have addressed the topic of women in engineering in other cultures, the cross-cultural impact of international students in a different culture has not been considered. Comparison of gender inequity in undergraduate engineering cultures of the U.S., Jordan and Malaysia did not include any cross-cultural influences [3]. A study [4] on female Malaysian engineering women sought to understand the aspects that factor into females' persistence in engineering. However, this study focused on women in industry and did not investigate the reasons for women's career choices. This project seeks to understand the cultural influences in engineering degree choice by posing the research question "***How do engineering students from Morocco and the United States describe the cultural reasons that factored into their choice to pursue an engineering degree?***" We want to understand the messages the Moroccan students received throughout their childhood and adult life that may have led to an engineering career choice.

Messaging is a powerful tool that can bring about meaningful change. For example, the "reform movement (of cultural change) in engineering education" [5] was ignited by ABET's outcomes based accreditation, which focuses on student learning [6]. Also, the National Academy of Engineering [7] study report "Changing the Conversation" encouraged the engineering community to offer a more diverse face to students [8]. As a result, departments that embrace

cultural change may be breaking the traditional stereotype of engineering being a rigid, linear, efficient, and pragmatic way of thinking [9].

Theoretical Lenses

The theoretical framework consists of two models, the first being modern expectancy-value theory which is based primarily on Atkinson's model [10]. In this model, achievement motivation, performance, choice, and persistence are linked to an individual's expectancy and values. In this model, choice is assumed to have a cost, and if the cost is too high, the choice may be eliminated. However, relative value and probability of success of various options are also critical determinants of choice. Expectancy in this context refers to an individual's belief of how well they will do in an impending task. The model differentiates task value into four components: *attainment value* (i.e., importance of doing well), *intrinsic value* (i.e., personal enjoyment), *utility value* (i.e., perceived usefulness for future goals), and *cost* (i.e., competition with other goals) [9]-[13].

Our theoretical framework also include Hofstede's cultural dimensions theory. This model focuses on cross-cultural communication and provides a description of the relationship between the values and behavior of the members of a society using a comparison scale. The effects of a society's culture on the values of its members, and how these values relate to the individual's behavior [14] are evaluated. Hofstede's cultural dimensions are:

- a. Individualism (IDV) relates to the strength of the ties people have to others within their community. A high IDV score indicates loose connections and a lack of interpersonal connection.
- b. Masculinity (MAS) refers to the level a society maintains its traditional male and female roles. High MAS scores are found in countries where a man is expected to be the provider.
- c. Uncertainty (UAI) is related to the degree of anxiety that society members feel when in uncertain or unknown situations. High UAI scoring nations try to avoid ambiguous situations whenever possible.
- d. Power Distance (PD) refers to the degree of inequality that exists and is accepted among people with and without power. A high PD score indicates that society accepts an unequal distribution of power.
- e. Time Perspective refers to the degree the society values long-standing as opposed to short-term traditions and values.
- f. Indulgence refers to a measure of happiness (whether or not simple joys are fulfilled). Indulgence in a society is defined as "a society that allows relatively free gratification of basic and natural human desires related to enjoying life and having fun".

Data Collection

We are targeting seniors and first-year graduate students in Aerospace and Mechanical Engineering majors due to the degree program similarities. Students from both majors are asked to complete a pre-interview demographic survey, which contains questions regarding participants', parents', and siblings' educational level. The survey includes open-ended questions regarding motivation. It also contains parts such as: "*In a few sentences please tell me the reasons you decided to pursue an engineering major*". The survey was built using previously existing surveys[15]-[17].

Data collected with the pre-interview survey is used to select interview participants with the most interesting stories. Thus far, interviews have been conducted with 13 American students, and interviews with the newly arrived cohort of 17 Moroccan students is ongoing, resulting in a total of 30 interviews. This is within the acceptable range of interviews for a qualitative study [18]; however, we will continue to interview until we reach saturation in our findings for each case [19]. We used semi-structured interviews to elicit a deeper understanding of cultural influences impacting participants' choice to pursue an engineering degree. This first set of interviews is focused on data collection, while the second set of interviews will focus on cultural adjustments (for Moroccan participants), member-checking, and clarification. We also piloted interviews with existing Moroccan students from older cohorts. We examined existing survey instruments such as [20], [21] to develop our interview protocol. For example, using the survey in the Blumenfeld study as a guide, we are asking expectancy-value specific questions such as: "*Do you feel that you are giving up anything by choosing the engineering path?*" For an affirmative answer, the follow-up question is: "*What things could you be doing instead?*" For a negative response, the follow-up question is "*Perhaps giving up time spent on your hobbies? Or time spent with family?*"[20].

Conclusion

This research will help us understand the impact of culture on students' motivations and goals. Results from this study can aid in identifying factors that are crucial for retention in engineering and increasing the U.S. STEM workforce. Identification of cultural factors that contribute to interest and motivation, thereby informing career choice, are important when designing curricula and messaging. The research plan is motivated by the need to increase the number of women in engineering and reduce the gender gap. This study will not only provide insight into primary factors that impact student motivations in career choice from a cultural perspective, but will reveal gender messaging in the U.S. as the Moroccan students adapt to the U.S. culture.

Future work

Future work may include women who were on the verge of choosing engineering but chose another career path. This work may also investigate other groups within the U.S. and Moroccan cultures. A quantitative approach may be implemented to produce more generalizable results that may produce a broader impact.

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References

- [1] R. A. Ellis, "Is U.S. Science and Technology Adrift," *Science and Technology*, 2007. .
- [2] T. U. . News, "The U.S. News/Raytheon STEM Index Shows America Will Have to Depend on Foreign Workers to Fill STEM Jobs," 2016. .
- [3] N. I. Abu-Lail *et al.*, "Persistent gender inequity in us undergraduate engineering: Looking to Jordan and Malaysia for factors to their success in achieving gender parity," in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2012.
- [4] S. Z. (1 Atiq 2), S. (3) Morton, N. I. (3) Abu-lail, A. A. (4) Kranov, J. A. (5) Kmec, and J. (6) DeBoer, "Women's motivation to pursue engineering education and careers: A case study of Malaysia," in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2018, vol. 2018-June, no. 2018 ASEE Annual Conference and Exposition.
- [5] E. Fromm and J. McGourty, "Measuring Culture Change In Engineering Education." ASEE Conferences, Albuquerque, New Mexico.
- [6] ABET, "Criteria for accrediting engineering programs," *Engineering Accreditation Commission*, 2003. .
- [7] N. A. of Engineering, *Changing the Conversation: Messages for Improving Public Understanding of Engineering*. Washington, DC: The National Academies Press, 2008.
- [8] S. . Malcom, "The Human Face of Engineering," *J. Eng. Educ.*, 2008.
- [9] E. H. Schein, "Three Cultures of Management: The Key to Organizational Learning.," *Sloan Manage. Rev.*, 1996.
- [10] J. W. Atkinson, "Motivational determinants of risk-taking behavior," *Psychol. Rev.*, vol. 64, no. 6 PART 1, pp. 359–372, 1957.
- [11] J. S. Eccles and A. Wigfield, "MOTIVATIONAL BELIEFS, VALUES, AND GOALS," 2002.
- [12] J. S. Eccles, A. Wigfield, and U. Schiefele, "Motivation to succeed," in *Handbook of child psychology: Social, emotional, and personality development.*, Vol. 3, 5th ed., N. Eisenberg, Ed. Hoboken, NJ: John Wiley & Sons Inc, 1998, pp. 1017–1095.
- [13] Jacquelynne S. Eccles, "GENDER ROLES AND WOMEN'S ACHIEVEMENT-RELATED DECISIONS," *Psychol. of Wmn Q.*, vol. 11, pp. 135–172, 1987.
- [14] G. Hofstede, *Cultures and organizations: Software of the mind*. 1991.
- [15] R. L. Kajfez, M. J. Mohammadi-Aragh, A. Clark, S. Sassi, and J. Petrie, "Board 29: Initial Qualitative Exploration into First-Year Engineering Community and Identity," in *2019 ASEE Annual Conference & Exposition*, 2019.
- [16] D. Grimes and J. Mohammadi-Aragh, "A Discussion of the Barriers Present to Female Engineering Students," 2017.
- [17] R. McFalls, J. Mohammadi-Aragh, and R. Sullivan, "Development of a Survey for Student Backgrounds Affecting Engineering Success."

- [18] M. Q. Patton and M. Q. Patton, *Qualitative research and evaluation methods*. Thousand Oaks, Calif.: Sage Publications, 2002.
- [19] I. Seidman, *Interviewing as Qualitative Research: A Guide for Researchers in Education and the Social Sciences*. Teachers College Press, 2006.
- [20] J. Eccles, A. Wigfield, R. D. Harold, and P. Blumenfeld, "Age and Gender Differences in Children's Self- and Task Perceptions during Elementary School," *Child Dev.*, vol. 64, no. 3, pp. 830–847, Jun. 1993.
- [21] E. S. Chiang, S. P. Byrd, and A. J. Molin, "Children's Perceived Cost for Exercise: Application of an Expectancy-Value Paradigm," *Heal. Educ. Behav.*, vol. 38, no. 2, pp. 143–149, 2011.