



Women's Motivation to Pursue Engineering Education and Careers: a Case Study of Malaysia

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Women's Motivation to Pursue Engineering Careers in Academia versus Industry: A Case Study of Malaysia

Abstract

The participation of women in engineering in undergraduate programs and in the engineering workforce in Malaysia stands in contrast to the systematically low proportions of female engineers in the United States. What factors contribute to this marked difference? To begin to answer this question, the research team considers retrospective personal accounts of career decision making of 38 female engineering faculty members and employed practicing engineer alumni (PE) from Malaysia's top engineering school. We conducted a case study using focus groups in order to capture descriptions of Malaysian female engineers' curricular and career decisions. Academic engineers speak of their desire to teach, but also of the "appropriateness" of their careers for women, especially for married women. On the other hand, female PEs spoke of choosing industry to fulfill a desire to demonstrate engineering capabilities, as well as being enticed by the financial benefits of industry. Overall, these women's voices afford us the opportunity to begin to understand career decision making in a country where women are well represented in engineering. This paper is part of a larger study which contributes to the literature that seeks to understand why women pursue and persist in engineering as a curricular and career choice.

1. Introduction and Motivation

Although the underrepresentation of women in engineering in the United States has been studied for decades in great depth, the bulk of research efforts have focused on the important time during undergraduate study when curricular choices are made. Less research has been devoted to women in industry, where roughly 70% of scientists and engineers are employed [1], or women engineering faculty, where women's presence can potentially shape the gender composition of the field. This work has also been concentrated on understanding the US context, where women receive only 19% of engineering degrees [2]. Despite recent studies on women dealing with workforce climate or academic role models, we still have a limited understanding of the comparative cultures in engineering industry and academia, or of the push and pull factors that inform women's decisions to enter each respective sector. More importantly, there is vanishingly little work on women's decisions to enter different engineering careers in contexts where women are well-represented.

In our paper, we discuss participation of women in engineering in Malaysia, a context where women represent a high share of both academia and industry (e.g., overall, 45% of the engineering workforce) [3]. Findings from the 2013 Malaysian MWFC Women in the Labor Market Study conclude that women are about 46% of the public and 51% of the private engineering, manufacturing, and construction work sector [4]. Studying the Malaysian context will help us gain purchase on the way choices are driven by "preferences for science" [5], reflective of broader societal perceptions of what is "appropriate" for women, or related to other factors that have not yet emerged in USA-centric research.

Malaysia is one of three cases in our larger project studying women's participation in engineering in three predominantly Muslim Countries (PMCs): Malaysia, Tunisia, and Jordan. We chose these three countries because they represent three cases with distinct geographical regions, cultures, economies, socio-cultural, legal, political, and education systems in the Muslim world. Moreover, these three countries boast a much higher representation of women in engineering compared to United States, with Malaysia having the highest representation. Within each country, we partnered with the major flagship public university that offers engineering degrees.

If we understand women's career selection decisions in engineering, we can better understand both perceived and tangible barriers into entering and persisting in either an industry or academic career (as in [6]). Further, we can more fully understand the nature of work and decision-making in two of the most important contexts in which engineering is practiced: industry, on the one hand, where the bulk of engineers work, and academia, where future engineers are trained by faculty and role models. (Several studies have found that in the United States, higher education institutions with higher proportions of women STEM faculty have higher proportions of women STEM students [7]–[9].)

In the remainder of this paper, we summarize the research that describes choice-making in the careers of scientists and engineers. We describe the social science and engineering education research that touches on career choice-making in STEM. Following this, we describe our methodological approach, sample, and analytic strategy. We use the constant comparative method to analyze qualitative data gathered by means of focus groups and interviews with 38 Malaysian female engineering faculty and PEs. Our analysis describes three broad themes: (1) factors that pull women in academic careers, (2) factors that pull women into industry careers, and (3) distinction between pull factors in academia and industry. Finally, we discuss implications and future directions for this worker within the context of our larger study.

2. Prior Literature on Choosing Engineering in the Academy vs. Industry

For nearly 60 years, the National Science Foundation (NSF) has tracked information about USA PhD recipients, their post-graduate plans, and their employment experiences well beyond graduation. At least in the USA, most PhDs work in academia, but this number is on the decline [10]. The tracking of this information by the NSF has led some researchers to ask what makes scientists and engineers choose the kinds of jobs they do. Yet, the research on self-selection into an academic versus industry career in engineering is limited. To begin, almost all of it is quantitative in nature, much of it focuses on STEM PhDs in general, and almost all of it is performed on samples in the U.S. without much attention to the way any single group (e.g., women) make these career decisions. In the following sections, we describe the research we are using to ground our current study in.

2.1. Career Preferences of Students in the United States

This area of research has identified several factors shaping industry versus academic career preferences in STEM fields. Because most of the research about career preferences (academic versus industry) comes from doctoral students who have not yet started a job in either sector [5], [11], we are limited to knowledge about early-stage perceptions that drive later decisions. From

this limited body of literature, we learn that a key feature of sector choice is the perceived job attributes in each sector. Students with a “taste for science,” namely a preference toward freedom to choose research projects, the chance to publish, and interest in conducting basic research, normally prefer academic careers.

We also know that interest in academic careers wanes over time in graduate school for PhD students in science and engineering and that the decline is driven primarily by a mismatch between their emergent job attribute preferences and what they know an academic career provides, NOT primarily due to a lack of jobs or perceived lack of jobs in academia [11]. In other words, respondents (current students) explained that they entered graduate school with a strong preference toward an academic career, but three years later, nearer the end of their graduate training, about a quarter of students lost an interest in an academic career. In their study, more men started their doctoral training with an interest in academia than did women (83% vs. 75%), but the same share of women and men report a decline in interest in academia (approximately 24% of both groups). Those concerned with salary, access to resources for research, and doing “downstream” research tended to prefer industry jobs [11].

2.2. Career Preferences of Employed Scientists and Engineers in the United States

We have much to gain from speaking to engineers already in a job; from them we can learn about what their expectations prior to job entry were and, in turn, how their expectations mapped onto their experiences. Any slippage between expectations and reality is relevant for understanding the workplace experiences of engineers, especially as it might relate to stopping out of engineering work in either sector. One such study that queried employed scientists and engineers about their career choices [12] focused mainly on the ways an interest in basic versus applied science and greater desire for non-monetary returns (i.e., job security, location, degree of research independence) mapped onto career choice. Overall, these researchers found that in academia, the higher ability scientists (measured by receipt of a grant as a doctoral student, ranking of PhD program, time to degree, and parental education levels) select basic over applied research and that the earnings of basic scientists are initially lower than those of applied scientists. Those who enter industry are not different in terms of ability, and their earnings look similar. Scientists and engineers with preference for advancement opportunities, intellectual challenges, independence, among other things (what the authors call a “taste for science”), select academia over industry. This is based on the assumption that industry science/engineering jobs are more restrictive in terms of task and expectations. The authors in [12] did not find, nor did they hypothesize about, differences in the way gender relates to career choices, so their work cannot shed light on women’s career choices, per se. Nor did they have data on what a student thought each career entailed.

To study whether new PhD students in certain STEM fields have accurate information on potential employment outcomes, another study drew on two different samples: roughly 4,000 science and engineering PhDs *and* recently employed PhDs [13]. They studied the “preferences” of these groups and found some differences in the preferences and employment experiences of women and men. (Note, the authors point out that student “preferences” may be more about gender-related “expectations” than about preference or taste.) For the most part, women “preferred” non-academic work over industry work compared to men, and more men were

employed in industry than are women, especially in electrical engineering and computer science (and these men earn more than their academic-employed counterparts). Relevant here is their conclusion that in electrical engineering, men seemed to be substituting industry work for academic work, and women appear to be taking academic employment that is “leftover” or available to them.

2.3. Cross-national Differences in Women’s Engineering Participation

There is limited work parsing out the national and cultural differences that inform higher participation of women in engineering in certain countries, but we can draw on cross-national quantitative work in sociology, as well as our group’s prior studies. Although previous work [14] found that countries with high gross domestic product per capita (GDPPC) had greater gender typing of curricular fields (e.g., viewing engineering = male or nursing = female) than those with low GDPPC, two of our smaller, foundational studies [15] and [16] found through interviews of women who chose engineering as a field of study that Jordanians and Malaysians may gender-type subfields of engineering rather than engineering as a whole. For example, there is near gender parity in enrollment in certain subfields of engineering in Malaysia (e.g., chemical, industrial, and computer engineering). In some cases, there are more women enrolled in these subfields compared to men.

In other work stemming from this same project [16], we explored how Malaysian female engineering undergraduate students talked about their pathway into, experiences in, and broader societal perceptions of their curricular field of choice. Our focus group conversations with this group of women was revealing in what they did not necessarily discuss: few undergraduate students described wanting a career in academia, whereas most expressed interest in an industry job. Some mentioned teaching (academia) as a “back-up” plan if their plans to find an industry job fell through. The undergraduate students expressed interest in engineering industry work despite their recognition of possible discrimination and unequal pay there. They explained that certain industry jobs were “off limits” for them as women; most recognized that engineering work done on site (as in the oil extraction industry, for example) was limited for women, that women are supposed to “do engineering” in office sites [17]. The Malaysian undergraduates fairly consistently voiced “pulls” of engineering industry jobs, so this motivated us to understand how employed engineers in both sectors (academia and industry) described their choices.

3. Research Questions

Our central goal in this study is to describe what motivates women in Malaysia to persist in engineering as a curricular and/or career path. In this study, we are particularly interested in the choices that informed women’s trajectories into academic versus industrial work. To accomplish this goal, we ask two research questions:

1. What do women describe as “pull factors” into their chosen career sector (academia vs. industry)?
2. What distinctions do women make between the pull factors between these two types of careers? In other words, we consider how, if at all, women in faculty and industry roles differently weigh the pull factors or describe different factors entirely?

4. Research Methodology

This paper uses a case study methodology [18], employing focus groups and interviews for data collection and the constant comparative method for data analysis [19]. We purposefully sampled a partner institution (University Teknologi Malaysia – UTM) because of its status as a major engineering flagship public university. We consider three embedded units of analysis (EUA): undergraduate students, faculty, and practicing engineers (PEs). We collected data from 19 undergraduate students, 22 faculty, and 16 PEs. The focus of this paper is on women who have completed their training (faculty and PEs), so the 38 women we interviewed have completed their engineering training and are now employed (though we draw on our previous work on undergraduates [16]).

4.1. Research Design

The Malaysian case study presented here is part of a multiple-case study. We use an embedded multiple-case research design, employing focus groups and supplemental interviews for data collection. We use Yin's definition of a case study [18]: an in-depth empirical inquiry that explores a phenomenon in its real-life context, especially when the boundaries between the context and the phenomenon are not clear [18]. Each country is one case, a sub-study within our larger study, and we look for patterns both within and between cases [18], [20]. By highlighting the experiences, implications, or effects of a phenomenon across settings [21], we will glean greater understanding of women's curricular and career decision-making process.

In each country, we conducted focus groups with each of our EUAs—undergraduate students, faculty members, and PEs—in the three country sites. In this particular paper, we explore the patterns of career decision-making within and across two EUA (faculty vs. PEs) in the Malaysian context. Focus groups were chosen to illuminate the social and psychological mechanisms underlying women's educational and work choices and any perceived structural constraints and opportunities shaping those choices. The study of women in multiple sectors of the workforce allows us to gain greater insight into perceptions and practices that influence women's entry and retention in engineering, and in our discussion below we situate our findings on employed engineers with our work on undergraduates' perceptions.

4.2. Sampling

University Teknologi Malaysia (UTM) is our Malaysian case. It is the most prestigious, elite public “flagship” university in Malaysia that offers engineering degrees. UTM offers engineering degrees in civil, electrical, chemical, and mechanical fields. We identified three sampling frames corresponding to our three EUAs (undergraduate student directories, faculty directories, and alumni lists) maintained by UTM, with the help of our local collaborators. From these sampling frames we selected focus group and interview participants representing diverse engineering disciplines, socioeconomic and geographic backgrounds, time in the workforce, and prior experiences. In all, we collected data from 19 undergraduate students, 22 faculty, and 16 PEs. Our sample for this paper comprises the 38 women who are faculty or PEs.

4.3. Logistics of Data Collection

Our data collection team consisted of a US team and a local team. The US team had two people (a PI and a graduate student) and the local team consisted of three people (two faculty members and a graduate student). The focus groups and individual interviews were led mostly by the PI with assistance from the graduate student. The graduate student was mainly responsible for the logistics of the interviews (e.g., starting and stopping audio recorders) as well as taking field notes during the interview. The local team was present during the focus groups and interviews, and their primary responsibility was to help contextualize questions for the participants or to translate into Malay if necessary. The local team also helped arrange the venue for focus groups, mostly on the UTM campus, arrange for snacks for the participants, and provide compensation to the participants.

4.4. Data Collection and Analysis Methods

We collected two different types of data: focus groups and individual interviews. The intention of conducting focus groups was to collectively ask a group of women about their decisions to pursue and persist in engineering. Further conversation helped to uncover overall tendencies and individual differences in women's paths in engineering (the how and why of that process). We also wanted to identify their individual accounts for being supported or discouraged in their choices. Audio files of focus group interviews were transcribed and translated into English (as needed) by a third party. Participants completed an online survey to collect demographic and family background information.

To analyze the focus group and interview data, members of the research team went through multiple iterations of reading and coding transcripts using Dedoose, a qualitative data management software that provides a suite of tools that help identify and explore patterns in interview transcripts. Following an inductive process (the constant comparative method – CCM) [19], members of the research team coded data without prompt categories. Coders created nodes and node hierarchies by reading through the raw interview text and identifying the topics that emerged and could be organized into themes. Two graduate student research assistants (one of whom was present at nearly all of the focus groups and interviews) coded each transcript, and two of the team PIs then identified sub-themes and themes. We checked inter-rater reliability of coding across individual coders. We used the constant comparative method to determine common themes and illustrative exceptions. CCM has four main steps [19]: (1) unitizing, (2) categorizing, (3) filling in patterns, and (4) member checks. We analyzed the similarities and differences emergent from each group conversation, making comparisons among the data of different interviewees of a given focus group and across focus groups.

5. Current Findings

We find that women's perspectives are certainly diverse, but that the factors that drew academic women into their career choice are notably distinct from those described by women in industry. We begin our presentation of results by describing the demographic makeup of the women in the sample. Then, we describe three themes and related sub-themes that emerge from the analysis of our data. First, we describe the unique pull factors relayed by academic women engineers, followed by the unique pull factors for industry women engineers. Finally, we describe the contrasting factors that pushed women in each respective sector away from a career in the other

sector, as both groups of women drew clear distinctions in their characterizations of academia and industry.

5.1. Sample Description

Table 1 includes relevant demographic and background information about the Malaysian faculty members and PEs sampled in our study. Briefly, about 73% of the faculty and 50% of the PEs are married. Furthermore, about 59% and 63% of the faculty and PEs have children, respectively. Most of the women rate their math ability above average or in the highest 10% compared to people of their age. The sample comes from a variety of engineering sub-disciplines, including electrical, mechanical, civil, industrial, chemical, and biomedical. Finally, roughly three-quarters of the participants are Muslim.

5.2. Theme 1 – Pull Factors into an Academic Career

From our analysis of the focus groups and interviews with faculty women, three main themes and subthemes emerged which guided their decision to pursue an academic engineering career: a personal desire to teach (subtheme 5.2.1), a personal or perceived societal view that academic careers suit women better than industrial ones (subtheme 5.2.2), and teaching is more suitable for women with families or who are married (subtheme 5.2.3).

5.2.1. Subtheme: A Personal Desire to Teach

Repeatedly, female faculty members expressed a desire—even a passion—for teaching. We heard numerous accounts of women academics at UTM describing their desire to teach, to interact with students, and to share their knowledge in a teaching setting as a salient pull into an academic career. Some even spoke of always wanting to be a teacher and role playing as a teacher in their childhood or, later in youth, teaching relatives and friends. The concept of *passion* surrounding teaching came up often, as described here:

“...teaching is actually one of my, I think, born to be passion because since even I haven’t started school I already teach a few of my nephews or friends to do something or to encourage them to...so I never feel bored on teaching, so I think that is why academician is quite part of my life...”

- Senior Lecturer, Mechanical Engineering, 14 Years

In addition to an expression for passion about teaching, some female faculty members described teaching as coming “naturally” to them. For example:

“...Why I stayed in this academy line is because it's natural for me because I know I'm good at teaching because my parents are teachers okay and I know that it comes to me naturally so why not? Because I feel that...maybe my students don't think that I am a good teacher but that's in another matter but I think that I can teach...”

- Associate Professor, Electrical Engineering, 29 Years

Furthermore, faculty women in our sample explicitly made it clear the difference between a practicing engineer and an academic teacher and described wanting to be a teacher, *not* a PE. One participant made it clear that despite having an engineering doctorate, she teaches, possibly as a way of making clear the distinction between being an engineer versus an academic:

“Well it is surprisingly, when you we're in primary school, anybody remember we were asked to fill in out our admission ambition, right? I put number one... ‘doctor’ number two... ‘engineer,’ number three... ‘lecturer’ and I...got all three, I have an engineering degree, I have a doctorate, although a philosophical doctorate doctor. My son six months a real doctor, and I’m teaching.”

- Professor, Mechanical Engineering, 28 Years

We noticed that a number of women were clear to point out their identity as a teacher, or even feeling like an academic, juxtaposed to having an identity of professional engineer. Often, these notions of having an identity as a teacher were assigned or pointed out by others, as was the case for a senior lecturer in engineering education (at UTM for 30 years): “My family, maybe they see me as a teacher.” Or another illustration:

“...To my family...they look at me not as an engineering line, they see me as an academic, you are teaching university students so it doesn’t matter if you’re from education, so that’s their perception because at the end of the day when they ask me with about what I did, I say I’m teaching the students, I did not tell them to discuss what I did, so they don’t see me as engineering lecturer. I did not tell them that this is what I did. They don’t see me as engineering lecturer, just see me as an academic...”

- Professor, Materials Engineering, 35 Years

Coupled with this teacher identity, women spoke of the support they received—from family, their graduate advisors, co-workers, and other engineers—to be an academic. More than once, women described encouragement to teach (as early as during the undergraduate training) and even suggestions that they teach and not pursue an engineering job in industry.

“...Yeah, yeah. I don’t like working in a hot I don’t like area so and another thing is when I’m doing my bachelor I worked closely with my head of department, at that time we start our careers...She always encouraged me to help her in teaching so at that time I already had been exposed with the academician’s process task so that’s where the interest grew...”

- Tutor, Chemical Engineering, 9 Years

Table 1. Demographic and Background Information for Malaysia Faculty and PEs Interviewed

Variable		Faculty (n=22)		Practicing Engineers (n=16)	
		Frequency	Percent	Frequency	Percent
Marital Status	Single	3	13.6	8	50.0
	Unmarried, but in romantic relationship	3	13.6	0	0
	Other	0	0	0	0
	Never Married	0	0	0	0
	Widowed	0	0	0	0
	Divorced	0	0	0	0
	Currently Married	16	72.8	8	50.0
Future Plans Involving Children	I already have children	13	59.1	10	62.5
	Does not plan to have children	0	0	0	0
	Plans to have children	3	13.6	5	31.3
	Prefer not to say	1	4.5	1	6.2
	Missing	5	22.8	0	0
Importance of Starting a Family	Extremely Important	9	40.9	5	31.3
	Very Important	8	36.4	3	18.8
	Moderately Important	1	4.5	5	31.3
	Slightly Important	0	0	0	0
	Not Important at all	0	0	1	6.2
	Missing	4	18.2	2	12.4
Importance of Building a Long-Term, Marriage like Relationship	Extremely Important	16	72.8	10	62.6
	Very Important	3	13.6	4	25.0
	Moderately Important	3	13.6	1	6.2
	Slightly Important	0	0	0	0
	Not Important at all	0	0	0	0
	Do not know	0	0	1	6.2
Math Ability Rating	Highest 10%	5	22.7	2	12.5
	Above Average	10	45.5	9	56.3
	Average	2	9.1	3	18.7
	Prefer not to say	2	9.1	2	12.5
	Missing	3	13.6	0	0
Engineering Subfield	Electrical	4	18.4	0	0
	Civil	0	0	1	6.2
	Mechanical	3	13.6	1	6.2
	Other	5	22.7	9	56.3
	Industrial	1	4.5	1	6.2
	Undecided	0	0	0	0
	Chemical	5	22.7	1	6.2
	Biomedical	1	4.5	0	0
	Missing	3	13.6	3	18.8
Faith	Muslim	18	81.8	11	68.8
	Buddhist	1	4.6	2	12.5
	Hindu	0	0	1	6.2
	Christian	0	0	1	6.2
	I do not give religious things much thought	3	13.6	1	6.3

A senior lecturer shared her story:

“...my ambition is I want to be a teacher, not to be an engineer because one time during my study and the degree in year four I'm going for practical training, so one of the engineers see me and he say that, 'You should be a teacher, not an engineer.' So that's why I feel that no, I cannot be an engineer. I should be a teacher and then, thank God, ... because I also get quite a good result and then UTM appointed me as a lecturer, so I'm quite happy...”

- Senior Lecturer, Engineering Education, 30 Years

This consistently articulated passion and desire to teach may be a reflection of messages that women continuously receive describing academia as a suitable career for women and engineering industry as the placement for engineering men. We describe this sub-theme in the next sub-section.

5.2.2. Subtheme: Academic Engineering is a Career for Women

Academic engineering was described by many as an appropriate space for women, especially in contrast to applied engineering (i.e., engineering in industry or on-site engineering jobs). Multiple women spoke of academic engineering as something that women do, sometimes because their parents indicated so:

“Yes, of course. Because normally when we talk about engineer so most of the person will focus that oh, male oh! Male should be as an engineer compared to a female. Because during my study I have my colleague most of them female be are teacher, only one or two person now as an engineer. The rest are all convert to be a teacher.”

- Senior Lecturer, Engineering Education, 30 Years

A senior professor narrated her experience by saying:

“...she told me that [t]here is a vacancy in the chemical engineering department and my parents are, they were both teachers, so they encouraged me to apply, they said that it's good for you to have an academic career since you're a woman so then I tried my luck and I got the job. That's how I started.”

- Senior Professor, Chemical Engineering, 30 Years

Further, respondents described that when a female student expresses interest in industry, many people around them express skepticism at the idea, as when one faculty member explained:

“...so when I talk to my students, the female students...I'm quite skeptical when they say they want to be an engineer. I ask them, 'You really know what you are going into?' ...”

- Associate Professor, Electrical Engineering, 29 Years

The alignment of academia with women and industry with men stems from both personal impressions of the field and from women professors' observations of their own students. Women in our sample noticed that female students tend to, for the most part, choose academia after completing their engineering degrees whereas men choose industry. Academia as a "female space" is encouraged by graduate advisors or general societal impressions of both what is best for women's and what is best for men's interests:

"...The technical things. Men like more do the technical things compared to the academician they don't really like to teach someone...but they [men] like to do practical, do hands-on, the industry..."

- Tutor, Chemical Engineering, 9 Years

5.2.3. Subtheme: Academic Engineering Compatible with Marriage and Family

One frequent way academic engineering is described as "better" for women is in its alleged compatibility with marriage and family. Female respondents were told, primarily by their parents, that academic jobs are more suitable for married women and even advised, in some cases, that following marriage, a woman should switch into an academic career. We note here that the message to married women (or women about to be married) is that academic engineering is suitable; none of the women we spoke with indicated pressure for them to leave the labor market entirely once married. Instead, the shift they were encouraged to make was from industry into academia:

"...After graduate going into working environment. Yes, I decided to do engineering first because, actually in my mind I never think about teaching. But after several month of I worked as engineer, and my mother said, "Your face looks stressed." And going back late at night and overtime is on that's all make a little bit difficult for the parents but for me, I think it's normal...after several months I decided to marry, so my parents said, "You just quit the job and apply for academic."

- Senior Lecturer, Mechanical Engineering, 8 Years

A senior lecturer shared her experience of joining academia once it was time for her to get married:

"I forgot to answer why I involved in education, the reason was, at that time I worked in a factory and then afterward, after one year then I want to get married, so my mom said, Okay, better I involved in education instead of working in the field."

- Senior Lecturer, Industrial Engineering, 16 Years

The faculty we talked with recognized that, as women, they were primarily responsible for the care of their families and that the notion of combining family and work was continually on their minds. In fact, some women described their family as coming first, as when a senior lecturer in Industrial Engineering (at UTM for 16 years) noted, "I want to give to my family first then for my career is the just second." In one instance, a respondent recognized that there would be no

substitute for her role at home (yet in her academic workplace, there are others who could do her work), and this recognition led her to advise other women about the importance of family:

“But yes I see family come first, I have gone through it...and I feel that in the academy and everywhere in Malaysia is I think women here are tougher, why they have extra baggage, you know they take care for the family, know that even they have to manage even if they don’t do the cooking or planning, they still have to manage and they are expected to do that in...Malaysia. So to me yeah, super woman.”

- Professor, Mechanical Engineering, 28 Years

A professor of mechanical engineering shared her opinion about the importance of family:

“...when it comes to choice between family and work I normally advi[s]e that even women lecturers they take care of [their] family first because I found [the] hard...way in the university you are dispensable and your family is not... I have to make sacrifices for the universities and...when there was a choice, they will just push you aside and just select the best, I mean regardless of what you have on that. Yes, but family you can’t do that. So I advise young female lecturers, you know they have a choice, they need to go abroad and take care of your family...”

- Professor, Mechanical Engineering, 28 Years

Interestingly, a number of women explained that this supposed compatibility of academia with marriage and raising children was a myth; that in reality, the academic job’s requirements that one always work (i.e., academic jobs do not end at 5 p.m., but instead, academic work comes home with a lecturer at night) was in fact *worse* for family balance than an industrial job.

“...If you give the second chance, I think I will stay as an engineering. in fact... You know because when we got home we’re still thinking about our job... For engineer, okay? ...when they’re back home they can concentrate on in their different family...”

- Unknown Faculty

So while society, especially the women’s parents might have seen academic engineering as appropriate for married women, the image of appropriateness was not due to the necessarily flexibility of the job but more deeply connected to the inappropriateness of what was assumed to be outside, dirty, “tough” work that happened in the presence of men and in public in industry jobs. This image of practicing engineering work as dirty and physically challenging or unpleasant was echoed by respondents in industry, though they made the additional distinction between types of roles in engineering practice and disciplines of engineering work (subtheme 5.4.3).

5.3. Theme 2 – Pull Factors into an Industry Career

In speaking with PEs, we identified themes that described a markedly different set of factors related to their trajectory into industrial careers compared to these identified by academic

women. These included the complex (not universally positive) need or desire to prove oneself in an industrial context, often as a requisite for acceptance in the company's culture (subtheme 5.3.1). Our sample of PE women also articulated factors that were more unambiguously pull factors, likely related to their selection into the sector. These included a very clear and consistent discussion of the monetary and logistical benefits of working in engineering industry (subtheme 5.3.2).

5.3.1. Subtheme: Need to Prove Oneself and Demonstrate Capability in Order to be Recognized

One of the most prominent themes was also one of the more complex. PEs consistently described experiences in industry where an engineer would go through an initial period of training or a set of tasks where she felt the need to prove herself. This initial demonstration of her capabilities in engineering, handling technical challenges, or dealing with machinery or physical challenges were articulated as both a need and a desire to show her skills. The trial might be prompted by male colleagues, supervisors, or subordinates, usually implicitly. After proving herself, she would feel like she was then treated without any distinction as a woman and, perhaps, perceived more "objectively" than she might otherwise be in another sector.

As one woman described, she feels like she is required to re-prove herself in her role whenever there are new colleagues or subordinates who have not yet gone through the process of accepting her:

"...Even though it's like they're making you in their group but then it's like what's wrong in a girl being strong? Isn't it? It's so annoying. But for now the new comers will assume me so but after I showed them that I just can do anything then they'll be Okay fine, I don't want to have any problem with this girl anymore..."

- Professional Engineer, Wire Industry, 3 Years

Although some women described a sense of accomplishment or resilience in demonstrating their competence, for many, this toughness is born out of necessity or due to negative experiences faced. As a result of pointed, gender-based judgments about their engineering competence, the female PEs in our study had to muster additional resources to move forward in their day-to-day job duties and long-term career.

"...We said it is maybe because something we wanted. After that, I took that as a challenge for me for my current also I made a lot of changes. I changed all this thing then I go for auditing also and they say that okay so the engineer came in came already so my cautious it will be different, apart from others. I learned a lot. I changed a lot. Only the thing is I learned okay, 100% in the production line. But my ideas are always open..."

- Professional Engineer, Chemical Engineering, 2 Years

The need or desire to prove herself as equal was described in complex positive and negative ways. In a sense, this process set up a gendered "gatekeeper" for women to have to navigate. Once gone through this hoop, women in industry then had the perception of equality in their

work. This relates to their perception of one of the benefits of working in industry – more “objective” measures of quality and competence (subtheme 5.3.2).

5.3.2. Subtheme: Desirability of Salary and Auxiliary Benefits to Industrial Jobs

A prominent and unambiguously positive set of pull factors related to the logistical characteristics of work in industry were mentioned by the PEs. These included salary as a very prominent factor, as well as flexibility in and power over scheduling and the perception of more “objective” measures of competence. Most prominently, women identified salary as a widely understood and explicitly appealing factor in choosing to pursue a career in engineering industry. As one woman described, large industries pay well, in terms of both salaries and bonuses:

“...I’m thinking about engineer as well lots of money like he or she earn like. Even probably yes some kind of like if you are in big company yes you earn a lot like bonus and so on like PETRONAS, Shell and earn a lot. I have strong as well in technical things and so on. Sometimes a part of me think you become like a ... what do we call it? Working hard for other people?...”

- Professional Engineer, Oil and Gas, 2 Years

Salary was cited as a pull factor not only as an isolated incentive, but also as an important facet of convincing family members of the viability and desire of the women’s pursuit of a career in an engineering industry. As noted by the academic respondents, women’s families often perceived working in the engineering industry as a less viable option for women engineers. As such, women were thinking about ways of “convincing” their family that their choice was feasible and desirable. For some respondents, the characteristic of high salary in industry was a pull factor because of their families’ financial needs, as in this example:

“...Always, you know, 35 years ago, all you want to do, I’m the eldest in the family, all you want to do is make sure that you study hard, you get a good job, and you can help with the family, you can help with your siblings. I got four other siblings under me. That would be the focus area. You want to go into, I don’t think it’s any different. You want to, when you choose a career, you want to see what five years is going to be like, or you want to have an idea of what five years is going to be like, what are the career that’s going to be in demand so that you’ll have a good opportunity to have a job, rather than not...”

- Professional Engineer, Oil and Gas, 22 Years

Auxiliary benefits of industrial jobs in addition to salary were part of the perception of the sector as desirable, not because of its gender-appropriateness or the nature of the engineering work to be performed. In addition to salary, flexibility in the work was seen as a benefit. Specifically, this meant flexibility in hours and work assignments in particular areas of industry (e.g., consulting or starting one owns company). Further, the perception of objectivity in industry evaluations was seen as positive. Numerous respondents connected this idea of objectivity, merit-based evaluations to industry’s focus on a profit motive. As one respondent described, this meant minimizing gendered judgments of quality:

“...I think same now, because even the salary for woman and men is the same. It depends on your capacity ... They are looking for experienced and what you can do for the company...”

- Professional Engineer, Construction, 1 Year

PEs also described the nature of the work they did as a pull factor, often in contrast to the perceived nature of work in academia (see Subtheme 5.4.4). The financial and logistic benefits to working in industry were important to respondents (subtheme 5.3.2), enough so that they were motivated to go through a trial after trial to prove their competence to their co-workers (subtheme 5.3.1).

5.4. Theme 3 – Push Factors and Distinctions between Pull Factors in Academia and Industry

Themes 1 and 2 described specific and unique pull factors that the two respective groups described about their sectors. In addition to these pull factors, respondents also clearly described distinctions between the pull factors of the two sectors, often in direct comparison with each other. In other words, they described the perceived draws of each respective sector and, as would be expected, the draws of the sector they ultimately joined were often evaluated as better or more desirable. In some cases, respondents articulated “push” factors, or reasons why they were dissuaded from going into the other sector.

Academic Subsample

Not surprisingly, given it is the career choice they made, the female faculty members we spoke with largely described academia as having more positive attributes in comparison to industry.

5.4.1. Subtheme: Academia is more “Intellectual” than Industry

Among these positive attributes, female academics in our study were also clear that compared to industry, their academic jobs involved a more intellectual climate that involved deeper knowledge of engineering than that experienced in industry. Some women spoke of academics delving deeper into engineering problems and that professional engineers only dealt with things superficially. In addition to expressing academic work as being more intellectual, women also described colleagues as being more “intellectual” than colleagues in industry. To illustrate:

“...For me working in academic work world is much, much better than industry because we’re typically dealing with intellects, intellects people, so once we say they understand it easily. But their mentality also different, totally different from industry because they normally doing the routine work so their scope of thinking is also very limited but for us we try to ask explore more...we try to explore and find whatever what that you we want, to find...”

- Senior Lecturer, Industrial engineering, 16 Years

5.4.2. Subtheme: Academia is Less Corrupt than Industry

Another point made by female academics was their emphasis on the corruptness of industry. The corrupt atmosphere of industry, in fact, was in some cases a push factor driving women away from industry into academia. That is, women avoided industry in order to avoid corruption they deemed as prevalent there. Academia, some felt, provided “protection” from corruption which they believe to be part of industry:

“... I registered as a tutor...because I like to be an engineer, but this environment of engineering world is not, I'm not into that environment. I'm against corruption but I cannot control that corruption, so by being in this academic world I can somehow protect myself from being part of that and somehow I can teach my student to control and be integrity in their work when in their future...”

- Senior Lecturer, Civil Engineering, 6 Years

Practicing Engineering Subsample

PEs contrasted their work with the perception of work in academia in complicated ways. They noted that industrial jobs were inherently dirtier than academic jobs (subtheme 3.3), to the extent that this has made them rethink their workplace, but they made the further distinction between office work and “site” work. At the same time, they enthusiastically described the level of excitement of an industrial job in contrast to work in academia. This excitement outweighed complications and challenges in considering academia versus industrial work.

5.4.3. Subtheme: Perception of Industrial Jobs as Inherently Dirty

Respondents working in industry characterized industry work as inherently dirty. “Dirty” meant both physically dirty, profane in terms of the language used by co-workers on the job, and immoral in terms of some inappropriate or unpleasant interactions with male co-workers. Many women pointed out that, on the job, men would curse a lot, sometimes (though not always) affecting the workplace climate for women. As one woman articulated, for example:

“...Oh! The cursing, the cursing during my now ... In the work, yeah. ... And during now it's very, it's more than during my school...”

- Professional Engineer, Telecommunication Engineering, 1 Year

Respondents noted that the “dirty” nature of engineering industrial relevant work extended to the interactions she had to anticipate with male co-workers. One woman described the extra precautions she took to dress for a workplace environment that included male co-workers:

“...It depend on the company in Malaysia. Also, being a woman I think one thing you must really consider is our outfit because men, they have wide imagination even though you're wearing simple trousers. If this is my site, I need to wear something more like if I'm wearing L, I need to wear double XL...”

- Professional Engineer, Chemical Engineering, 4 Years

5.4.4. Subtheme: Perception of Industry as More Interesting and Less Boring

PEs frequently and unequivocally contrasted industrial work to academia in a positive light when talking about the nature of the engineering work itself. Work in industry was described as exciting, interesting, and new. On the other hand, academia was described by PEs as repetitive or boring. As one respondent described, her favorite part of the job was the novelty of working in a sector where she had to continuously learn new information:

“...The best part in my career as an engineer is I get to learn new things because when you meet people in conference, in meetings, you get to be exposed on new technology, on new way of doing things and on new standards and guidelines whether it’s in Malaysia or whether it’s overseas. Especially nowadays, with the internet and those kinds of things there’s a lot of things that you can actually get those information. But information will always be an information unless it’s being developed, it’s actually being used in real life. That’s what I like about being an engineer and realizing architects dream has always been satisfying and fighting with the architects. I think that’s the best part of me becoming an engineer...”

- Professional Engineer, Construction, 27 Years

Another respondent described her own interest in continuously changing tasks, and she was able to move flexibly between jobs in industry:

“...In every project there’s a different challenge, it depend, when I’ve been working, I’ve been doing it again and again but in the same, I think there’s more of this so that’s why I get bored, so I transferred in other company. Then I see there’s really more about this, other things. They need to make timeline to yourself when you want to learn...”

- Professional Engineer, Construction, 1 Year

Overall, PEs were open about choosing *against* a career in academia because it would lack the qualities they saw in an industrial positions including excitement and novelty. Teaching and research, by contrast, were described as boring, repetitive, and requiring a long time-scale. While academic engineers have to plan for multiple year time periods for the process of tenure, large research grants, and yearly classes that follow the set academic calendar, the industry operates on a more rapid turnover. As one woman described, she did not want to go into teaching because of the patience it would require:

“...Okay. I was studying in the States, I had the opportunity to have my, they call it the internship. I had the opportunity to do my internship in the oil and gas industry in Louisiana because Louisiana it’s quite close to Texas and all that. I get to go to the field and I get to get dirty, I get to meet the guys. There’s lots of things I’ll do with my hands and as I told you personally I know myself, I like to meet a lot of people but I don’t have the patience in teaching or I don’t have the flair in teaching. That’s why when I made the decision that I’m not going to the academic or profession, I suppose part of the exposure that I had was because of the fieldtrip, the internship, like that. That’s what actually made me that all along decided to actually get involved with the actual work...”

- Professional Engineer, Construction, 27 Years

Some PEs did bring up academic work in a positive light. Some mentioned future academic plans, including teaching or university-based research positions as potential future options. That is, some women were satisfied with their choice of industry *for now*, but would be open to academic work in the future, especially if their life circumstances changed. One respondent specifically noted that academic work was a backup plan for her in the future if she were to get married and have children. For others, mentioning academia as an option still open to them reflected reactions from their family's skepticism towards their jobs in the industry. Often this skepticism was rooted in a gendered concept of the appropriateness of academia for families.

6. Discussion, Implications, and Future Directions

Although there is very limited prior literature that directly informs our work, we see in our findings two interesting parallels with previous studies more broadly. First, we see identity formation as one of the most important factors informing women's choices as well as their understanding of their choices in retrospect. Second, we see distinct understandings of the nature of the engineering work in each sector, and it is the alignment of women's descriptions of engineering work with their job preferences that informs their choices and feelings of "fit".

We turn first to the idea of identity formation as affecting choice. We observed that emergent and realized identities in the two sectors are distinct and that these distinct professional identities shape women's description of the "pull" into each sector. For academic women, this is an identity as a *teacher*. Teaching, even over engineering, stands as the organizing characteristic of women and their perception of their work as engineering faculty members. On the other hand, women in industry identify as *engineers* as a professional identity. Moreover, friends, colleagues, and family members reinforced these identities, referring to female engineering faculty members as "teachers" and on-site female engineers as "engineers."

Previous work finds that engineering professional identity formation may start early in undergraduate studies as a way of adapting to the culture of masculine engineering work (not necessarily academic engineering [22]). Similar to the responses articulated in Subtheme 5.3.1, [22] finds that professional identity formation often involves or is enacted in order to manage male impressions of female engineers. Similarly, [23] found that female physics graduate students spent a great deal of energy concealing their female identity (personality traits they associated with being a woman, like smiling or laughing) for fear of not being taken seriously by their male colleagues.

We also see women's desire to teach (subtheme 5.2.1) as an identity also formed early. This identity as "teacher" may partly stem from implicit and explicit signals that women receive from others (e.g., teaching is best for married women, practicing engineering is dirty and tough, see subthemes 5.2.3 and 5.4.3) that for them, engineering is best done in a classroom (i.e., teaching) so the "teaching" identity may partly reflect a broader notion of the incompatibility of women with on-site engineering work (subtheme 5.2.2).

Although identity formation may play a stronger role than a "taste for science", we see that a secondary issue is the nature of the work itself as aligning with women's job preferences. In previous studies, STEM graduates view decisions to enter academia as related to a "taste for

science” [1]; that is, some chose an academic career in order to have freedom over research agendas, the opportunity to publish, and an opportunity to stay connected to a broader scientific community. By contrast, in our work, we see that a “taste for [science] engineering” leads women *away* from academia, a choice in line with the expectations society has for women, and into industry. The nature of engineering work – its excitement and the constant change of the job – is a pull factor for women into industry (subtheme 5.4.4). On the other hand, a “taste for teaching” pulls women into academia. Although a few respondents did mention teaching as a “backup plan”, this was not a primary characterization as in prior work [16]. Indeed, the nature of the work (whether the draw of teaching/conferring knowledge for faculty or engaging with cutting edge technology for PEs) were so much of a draw that push factors out of academia (e.g., long hours, frustration with the evaluation system) or industry (e.g., dirty work, seeming incompatibility with marriage) were outweighed.

This stands in contrast to work in the U.S., where women’s engineering professional identities and technical work is overshadowed by “identity negotiation” [24] and the formation of a gender identity. Regarding the latter, researchers have stressed that at least in the U.S., individual’s choices about field of study (and ultimately their career) are thought to reflect the development of one’s belief about who they think they are [25], especially who they are as a man or woman or simply, one’s expression of their gender identity [26]. More specifically, women and men draw on internalized gendered ways of being—gender schemas—in all of their experiences and these schemas become critical for interpreting opportunities, organizing personal identity, and shaping preconceptions [27].

For female engineers in our sample, their choice seems disconnected, or at least less relevant, to their gender identity. That is, while women fully recognized and could clearly articulate broad societal perceptions of the nature of engineering industry work as “tough” or “dirty” (i.e., “masculine”, see subtheme 5.4.3) and teaching as “less corrupt” and compatible with marriage (subtheme 5.2.3), these perceptions did not seem to shape women’s . Instead, these societal perceptions informed the way that respondents talked about the benefits and drawbacks of each sector. That is, academia is a good choice for those who want to get married (subtheme 5.2.2) and enjoy intellectual pursuits (subtheme 5.4.1) and industry is a good choice for those who want material reward (subtheme 5.3.2) and excitement (subtheme 5.4.4). The use of societal perceptions of engineering to shape career decisions reflects our findings from undergraduates [16] and mirrors prior work on STEM graduates and greater alignment with their job preferences, rather than assessments of the labor market [11], [26].

In closing, the findings we have presented offer important insight into the way female engineers make sense of (and use) general perceptions of engineering; unlike in the U.S. where women frequently avoid masculine-typed fields all together because they contradict one’s identity as a “woman” [25], [27], we observe that the Malaysian engineers in our sample do not necessarily cast their career choice as a reflection of their identity as women. Instead, they use societal understandings—many of them gendered (see subtheme 5.2.2, 5.4.3)—to frame the “good” in their selected career (and the “bad” in the career they did not choose). The focus group interviews with Malaysian faculty and PEs are part of a larger project that involved similar study of female undergraduate engineering majors in Malaysia and students, faculty, and PEs in Tunisia and Jordan. Preliminary analyses of the focus group data from Malaysian female

undergraduate engineering students [17] suggests that engineering is considered masculine-typed in Malaysia and that women recognize the challenge of engineering work. They also spoke of the possibility of differential treatment in the field because they are women. Additionally, they talk of support in their pursuit of engineering and expect their own success in the field. This research team's next step is to apply the constant comparative method to the analysis of groups within each case and subcases. Similarities between the undergraduate, faculty, and PEs depictions of engineering as masculine seem to be emerging, but it is too early to interpret what the implications of that may mean. Future work will include cross-EUA and cross-case analysis.

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