DEVELOPING AND PROMOTING ENGINEERING ENTREPRENEURSHIP IN MOROCCO: A THREE-PART INVESTIGATION

A Thesis in
Industrial Engineering

by

Samantha P. Adams

© 2013 Samantha Adams

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

August 2013
The thesis of Samantha Adams was reviewed and approved* by the following:

Scarlett Miller
Assistant Professor of Engineering Design and Industrial Engineering
James F. Will Career Development Assistant Professorship
Thesis Advisor

Zoubeida Ounaies
Associate Professor of Mechanical Engineering
Dorothy Quiggle Career Development Professorship

Paul Griffin
Professor of Industrial Engineering
Peter and Angela Dal Pezzo Department Head Chair
Head of the Harold and Inge Marcus Department of Industrial and Manufacturing Engineering

*Signatures are on file in the Graduate School
ABSTRACT

Entrepreneurship is fundamental to the wellbeing of an economy. As such, researchers have long tried to understand the skillsets required to be successful in entrepreneurship in order to develop effective teaching strategies to produce more entrepreneurs and spawn economic development. Of particular interest has been developing entrepreneurship skillsets during engineering education because technology innovations and ventures represent high growth potential. While the United States has invested much effort into understanding and developing these skillsets in engineering education, many developing regions have yet to develop an understanding of motivations/ barriers for pursuing entrepreneurship, educational curriculum or programs that supports entrepreneurship skill development or provide a network to connect businesses, entrepreneurs and students together. These types of activities provide a means to effectively develop entrepreneurs and thus jumpstart economies, which is vital in regions like Morocco that suffer from soaring unemployment rates – 25% or higher among recent college graduates – which has led to civil tensions. As such, it is important to study ways to teach and encourage engineering entrepreneurship in Morocco and other developing regions.

Therefore, the objectives of this thesis were to: 1. Investigate the effectiveness of a two-day day engineering entrepreneurship workshop in Morocco for igniting interest in entrepreneurship, 2. Examine the motivations and perceived barriers of Moroccan engineering students (male and female) for becoming entrepreneurs, 3. Explore strategies to encourage women to continue into engineering and science careers (both traditional and entrepreneurial), and 4. Promote engineering entrepreneurship in Morocco, and North Africa more broadly. A mixed methodology approach was used to answer these questions including qualitative analysis of focus groups and individual interviews, as well as quantitative analysis of survey data collected from a series of two-day engineering entrepreneurship stimulation workshops, held in two major Moroccan cities in 2013. In all, fifty-five Moroccan engineering students participated in this thesis research.
The results of this thesis provide valuable insights into Moroccan engineering entrepreneurship, offering: 1. A model of short-term engineering entrepreneurship education that effectively increases self-efficacy and interest, and that provides an alternative to traditional university courses, 2. Understanding of motivation and perceived challenges of Moroccan engineers who intend to pursue entrepreneurship, which can be used to generate targeted training in the future, and, 3. A theoretical understanding of the challenges that Moroccan women face in science and engineering, both in education and in their career paths. This knowledge is used to generate recommendations and response strategies for increasing engineering entrepreneurship interest and involvement in Morocco that can be generalized with caution to elite engineering students in other North African countries.
# Table of Contents

List of Figures ........................................................................................................ vii
List of Tables .......................................................................................................... viii
Acknowledgements ............................................................................................... ix

Chapter 1  Introduction ......................................................................................... 1

  Background & Motivation ............................................................................... 2
  Objective ........................................................................................................... 6
  Summary of thesis papers .............................................................................. 7
    Paper I – Sowing the seeds of entrepreneurship in North Africa: A United States-
     Tunisia-Morocco partnership ................................................................. 7
    Paper II – Investigating entrepreneurial motivations and promoting venture creation
     among engineers and scientists in Morocco........................................ 8
    Paper III – The scissor effect: Challenges and response strategies for encouraging
     Moroccan women to pursue engineering and science careers............. 10
  Encouraging engineering entrepreneurship with online resources .......... 11
  Discussion & Contributions ......................................................................... 15
  Conclusions ...................................................................................................... 16
  References ....................................................................................................... 17

Chapter 2  Sowing the seeds of entrepreneurship in North Africa: The United States-
     Tunisia-Morocco partnership ................................................................. 22

  References ....................................................................................................... 28

Chapter 3  Investigating entrepreneurial motivations and promoting venture creation among
  engineers and scientists in Morocco ............................................................ 29

  Abstract .......................................................................................................... 30
  Introduction ...................................................................................................... 30
  Background ...................................................................................................... 33
    Entrepreneurship in North Africa ............................................................. 33
    Teaching engineering entrepreneurship .................................................... 35
    Assessing entrepreneurship and entrepreneurial intent ....................... 37
  Summary and research questions ................................................................. 39
  Methodology .................................................................................................... 39
  Participants ...................................................................................................... 40
  Workshop details and assessment methods ............................................... 40
  Analysis and results....................................................................................... 43
    What motivates Moroccan engineers to become entrepreneurs? What deters them? 44
    How does gender affect entrepreneurial motivation, interest, attitudes, and self-efficacy
     of engineering students? ........................................................................... 47
    Is it possible to significantly change participant’s entrepreneurial attitudes, interest, and
     self-efficacy/entrepreneurial mind-set in a two-day workshop? ............... 50
Discussion

Moroccan undergraduates are motivated to pursue entrepreneurship to fulfill personal goals and aid in the development of their country, but face difficulties acquiring capital and finding assistance.

53

Men and women exhibit similar career plans, entrepreneurial motivations, interest, attitudes, and self-efficacy, with men demonstrating higher push influences.

55

Short-term programs can encourage entrepreneurial interest and self-efficacy.

56

Limitations & future work

57

Conclusions

58

References

60

Appendix 1. Surveys used

63

Chapter 4 The scissor effect: Challenges and response strategies for encouraging Moroccan women to pursue engineering and science careers

71

Abstract

71

Introduction

72

Related Work

74

Women in science and engineering in Morocco

74

Women in entrepreneurship in Morocco

76

Mentoring systems and practices in Morocco

77

Research questions and objectives

78

Methodology

79

Participants

79

Procedure

80

Findings

84

What factors contribute to the “scissor effect” of Moroccan female engineers?

84

What factors contribute to Moroccan women’s pursuit of technological entrepreneurial activities and what perceived obstacles exist?

87

How can mentoring be used to encourage women to enter the SET workforce in Morocco?

89

Discussion & Implications

92

Stereotyping, tokenism, and conceptions of raising children and family / work balance may contribute to attrition from engineering careers

92

In the face of obstacles, engineering entrepreneurship offers a viable outlet for women’s talents.

94

Female Moroccan engineers could benefit greatly from mentoring programs

95

Future Work & Limitations

97

Summary and Conclusions

98

References

100
List of Figures

Figure 1-1. Before and After Homepage Design .......................................................... 14

Figure 2-1. 2013 Marrakesh USTM workshop (left) and Mr. El Mouden, preparing to present (right)............................................................................................................. 22

Figure 2-2. Design activity in progress ............................................................................. 25

Figure 3-1: Brainstorming session (left) and prototyping session (right) for hands on design activity during one of the two workshops ......................................................... 41

Figure 4-1. Focus Group Collaging Activity ................................................................. 80

Figure 4-2. Focus Group Topics List .............................................................................. 81

Figure 4-3. Interview Script ......................................................................................... 83
List of Tables

Table 1. What factors are significant entrepreneurship motivators or deterrents? .................. 46

Table 2. Do motivations, deterrents, or future plans differ between men and women? .......... 49

Table 3. Did pre-/post- surveys demonstrate changes in self-efficacy or attitudes/interest? . 52
Acknowledgements

First and foremost I would like to acknowledge Dr. Scarlett Miller for believing, with little to no evidence, that I could do this and for all of her support and guidance along the way. Thank you for making me better than I knew I could be. I know that I couldn’t have produced so impressive a work without you and am so thankful that you were willing to befriend me and lead me through this marathon. I would also like to thank Dr. Zoubeida Ounaies for her crucial role in this journey. Although it was more difficult to coordinate three schedules than two, the value of having a second advisor – a second mentor, really – to provide perspective and assistance was innumerable. I am so honored to have been able to work with two such successful and ambitious women.

I would also like to thank my family and friends for supporting me through this – sometimes trying – process. I am sure that at times this undertaking has felt like an uphill battle for you as well and I can only hope that its completion is as rewarding for you as it is for me. Mom and Dad, thank you for always having faith in me (sometimes more than I had in myself). To my brother, Doug, thank you for being there for me. You were my first friend on campus and an admirable supporter throughout this experience, despite your enduring shock and disbelief that I was accepted into this Master’s program.

Finally, the United States, Tunisia, Morocco Technology Innovation and Entrepreneurship Stimulation (USTM-TIES) project and this resulting work was made possible by a grant from the United States Department of State through the BOOST program, award # S-LMAQM-12-GR-1232. I would like to extend thanks to Britelab members Arti Patel and Boyd Warwick-Clark for their assistance with this research, and to USTM alumnus Mr. Mohamed El Mouden for sharing his USTM experiences with me. Finally, I am thankful to Prof. Tahiri (Ecole Mohammadia) and Prof. Kaddami (Cadi Ayyad University) for their help and collaboration.
Chapter 1

Introduction

Attention has recently been given to the subject of entrepreneurship and whether it is teachable, investigating whether entrepreneurs are born or made. Research strongly suggests that entrepreneurship can be learned, particularly as measured through entrepreneurial self-efficacy and attitude evaluations (Borchers & Park, 2010; W. Lucas & Cooper, 2004; Wilson, Kickul, & Marlino, 2007; Zhao, Seibert, & Hills, 2005). Entrepreneurship, however, has faced difficulties in establishing itself as a distinct discipline, lacking a strong theoretical foundation or methodology that the community can call its own (Fiet, 2000). Subsequently, various approaches to entrepreneurial education have been devised, using drastically different content and approaches, some stressing practice and others theory. Of a survey of 18 entrepreneurship courses from as many institutions, 116 different subjects were covered, only one third of which were shared among the programs (Fiet, 2000). This definitional problem is compounded when examining developed vs. developing countries; as Refaat (2009) explains, in developed countries entrepreneurship education refers to innovation, creativity, and non-traditional thinking, but in developing countries it tends to focus on cultivating positive attitudes towards venture creation.

Many of the topics present in entrepreneurship education originate from different disciplines, highlighting the strengths and weaknesses of such interdisciplinary work (Fiet, 2000). In recent years, engineering entrepreneurship has gained particular attention, with technology ventures epitomizing high-growth potential (Hechavarria & Reynolds, 2009). Through the work of Dabbagh and Menasce (2006), engineering entrepreneurship has been explored as a way to motivate students, increase interest in engineering, and to offer an example of what students will experience as engineers in the real world. Students in the field have reported greater use of creativity and problem-solving strategies, and had a significant increase in professional skills (Dabbagh & Menascé, 2006). Universities across the United
States have started to institute entrepreneurship courses, minors, and programs in their engineering curricula (Bilen, Kisenwether, Rzasa, & Wise, 2005; Creed, Suuberg, & Crawford, 2002; Nichols & Armstrong, 2003; Ohland, Frillman, Zhang, & Miller, 2004; Standish Kuon & Rice, 2002) and literature suggests that entrepreneurship can be taught through traditional education methods (Borchers & Park, 2010; Wilson, et al., 2007; Zhao, et al., 2005). In other regions aside from the United States and Europe, the subject of engineering entrepreneurship, either education or otherwise, has received far less attention.

In part due to its role in economic growth, development, and job creation (Jack & Anderson, 1999), research has begun attending to entrepreneurship in developing countries like Morocco (Gray & Finley-Hervey, 2005; Gray, Foster, & Howard, 2006). Particularly, Morocco has been facing civil tensions due to high unemployment rates. In 2011, these increasing tensions led to protests that have since remained a common occurrence (Bensalam, 2012; Crowell, 2013; Fakim, 2012). With no sign of unemployment rates or frictions subsiding, it is important to encourage entrepreneurship in an effort to stabilize the Moroccan economy. This work contributes to existing engineering entrepreneurship knowledge by examining the motivations and deterrents of Moroccan engineering students considering entrepreneurship, investigating short-form entrepreneurial education alternatives, and exploring the perceived challenges of Moroccan women seeking to pursue science, engineering, or technology professions.

Background & Motivation

In early 2011, during a period now referred to as the Arab Spring, both Egypt and Tunisia experienced revolutions (Kirkpatrick, 2011a, 2011b). Since then North African countries, notably Morocco, have seen riots and protests become almost daily occurrences (Bensalam, 2012; Fakim, 2012; Patel, June 2011). Much of this civil tension relates to high un- and under-employment rates, particularly among college graduates (Bensalam, 2012; Fakim, 2012). Graduates prefer the stability of government
jobs, but an imbalance of available openings and numbers of new graduates has led to soaring unemployment rates among this young demographic (Fakim, 2012). One proposed approach to this problem is to increase the rate of entrepreneurship ventures, particularly in technology domains that have high growth potential (Refaat, 2009).

With a unique technical skillset and knowledge of recent technical advances, engineers represent an ideal population to cultivate entrepreneurial ventures. Despite having the necessary education, many youths are currently unable to find traditional employment in Morocco; the World Bank reports that unemployment among Moroccan youths with a university education is 25% for females and almost 29% for males (Kingdom of Morocco: Promoting youth opportunities and participation, 2012). As such, it is important to consider the best ways to teach entrepreneurship to engineers as well as how to incite interest in this subject among students in the region. One of the biggest challenges, however, is figuring out how to incorporate entrepreneurial training into a traditional engineering education; engineering curricula, both in the United States and Morocco, have little, if any, space to devote to additional courses. Most of the work on entrepreneurship education to date has focused on semester or year-long courses (Bilen, et al., 2005; Ohland, et al., 2004; Standish/Kuon & Rice, 2002; Wang & Kleppe, 2001). This traditional approach is problematic because it does not address the desire for flexibility that is often needed in order to accommodate entrepreneurial interest without compromising high engineering education standards. There have been a few recent studies that have explored the benefits of the week-long Enterprisers program, and revealed that participants experienced significant and lasting confidence gains (Cooper & Lucas, 2006; W. Lucas & Cooper, 2004), but the effectiveness of short-form or non-traditional engineering education methods, limited to begin with, has received little attention beyond the US and UK. This deficit leads naturally to the question: can short-term programs, particularly in developing countries, successfully raise entrepreneurial interest and self-efficacy without the time constraints of traditional courses?
In addition to examination of the impact of short-term programs on self-efficacy and interest gains, it is important to consider what current motivators exist for engineering students to pursue entrepreneurship in Morocco. Entrepreneurship provides economic growth and development benefits, stimulating job creation (Jack & Anderson, 1999) and, as such, can encourage economic stability. In part due to its role in economic growth, research has started to investigate entrepreneurship in developing countries such as Morocco (Gray & Finley-Hervey, 2005; Gray, Foster, & Howard, 2006; Premand, Brodmann, Almeida, Grun, & Barouni, 2012; Refaat, 2009). This research, however, is limited to general entrepreneurship, eschewing the innovation and technology focus of engineering entrepreneurship. In order to tailor future efforts to support and encourage engineering entrepreneurship, we must first understand what drives (and deters) the student engineering population. In examining this question, both push and pull factors for entrepreneurship must be considered; push factors encourage entrance into entrepreneurship out of necessity or in order to escape something, whereas pull factors include opportunities and positive factors. Deterrents and future career plans also play a pivotal role in developing a comprehensive understanding. Armed with a more complete understanding, programs can be adapted and recommendations created to encourage entrepreneurship among engineers in the context-specific case of Morocco. To address this, the following research question was asked: what motivates or deters Moroccan engineering students from pursuing entrepreneurship?

With the stability of North African nations remaining elusive, it is key that human capital is employed to its full capacity. While both males and females face high unemployment in Morocco, women’s representation in science, engineering, and technology (SET) domains faces a dramatic decline after graduation (Qayyum, 2012) and women have fewer engineering and technological job opportunities than men (Hassan, 2000). The specific reasons as to why female Moroccan engineers are underrepresented in industry are unexplored, a void which this work seeks to inform. As a male-dominated industry, lack of inclusion of women in engineering has been identified in SET fields in the United States, with the suggestion that such social cues may drive women from the field (Marra, Rodgers,
Shen, & Bogue, 2009). Therefore, it is important to consider gender when exploring Moroccan engineering entrepreneurship motivations, since issues of inclusion/exclusion and societal gender norms may contribute to women’s interest or participation. Although some work has been done in the area of Moroccan women’s entrepreneurship (Gray & Finley-Hervey, 2005), little has focused on technology venturing or the specific experience of female scientists and engineers. This led to the questions: how do Moroccan women perceive technological entrepreneurship and what challenges do they face?

Although much attention has been given to women’s attrition from science in the United States, complete with proposed theories and strategies for recruitment and retention, there is little available research about the issue in Morocco or North Africa. In the United States, women represent a mere 18.4% of engineering undergraduates (Yoder, 2012) and only 14% of the engineering workforce (Beede et al., 2011). In North Africa, on the other hand, women account for a more generous portion of the engineering student population, representing 50.8% of new students in Morocco (Statistiques Universitaires 2010-2011, 2011) and 34.3% of Tunisian engineering students (L'enseignement superieur en chiffres: Année universitaire 2011/2012, 2012). While not formally documented, it is acknowledged that this advantage is lost after graduation in what is referred to as the scissor effect (Bahmani, et al., 2012), where representation of women in SET careers is far lower than in education (Dewedar, 2012; Qayyum, 2012). Specifically, the research questions asked were: what factors contribute to the decreased representation of women in SET careers post-graduation and how can we develop response strategies to these factors?

Taken together, these subjects of motivation, increasing interest and self-efficacy through education, and women’s involvement provide a foundational overview of the current situation of engineering entrepreneurship in Morocco and provide a series of recommendations for its support. Recognizing this need for engineering entrepreneurship in North Africa, the United States Department of States is supporting a program developed by the Pennsylvania State University and the Massachusetts Institute of Technology to teach engineering students and young professionals the innovation, creativity,
entrepreneurial, and communication skills necessary to successfully pursue technology venturing. This United States-Tunisia-Morocco Technology Innovation and Entrepreneurship Stimulation (USTM-TIES) program aims to promote interest and positive attitudes as well as to teach fundamental innovation and creativity approaches. As such, its annual workshops in Morocco provided an ideal venue for investigating the lingering questions of engineering entrepreneurship in North Africa and as such were leveraged in the research conducted for this thesis.

**Objective**

The objectives of this thesis were to answer the research questions identified above. Specifically to investigate: the effectiveness of a two-day day engineering entrepreneurship workshop; the entrepreneurial motives of Moroccan engineering students; the perceptions that Moroccan women have of technological entrepreneurship; what challenges Moroccan women perceive in pursuing (engineering) entrepreneurship; what, if any, challenges Moroccan women experience when entering engineering and science fields; and strategies to encourage women’s persistence into related careers. The first paper, to be submitted to *IEEE Spectrum* for consideration (see Chapter 2), discusses the background and motivation of the USTM-TIES program, its programmatic evaluations, and offers the case of a successful alumnus who returned to share his experience. The second paper of this thesis, submitted to *Entrepreneurship and Regional Development* (see Chapter 3), examines the benefits of short-form entrepreneurship programs and identifies what motivates and deters Moroccan engineering students from pursuing entrepreneurship. The final paper of this thesis, submitted to the *Journal of Engineering Education* (see Chapter 4), explores the experiences of female engineers in Morocco, using a combination of focus groups and interviews to inquire about perceived challenges, perceptions of entrepreneurship, future plans, and the role of mentors and role models. The summary of these papers is presented next, followed by a general discussion of findings and contributions to the engineering domain.
Summary of thesis papers

The three manuscripts completed as part of this thesis examine different aspects of engineering entrepreneurship in Morocco: Paper I introduces and describes the USTM-TIES program, the pool of participants that was used to study the delineated research questions. Paper II answers a key question raised by a review of the related work: can short-term programs, particularly in developing countries, successfully raise entrepreneurial interest and self-efficacy without the time constraints of traditional courses? Also answered in Paper II is the research question: what motivates and deters (male and female) Moroccan engineers from pursuing entrepreneurship? Finally, Paper III asks: what factors contribute to the decreased representation of women in SET careers post-graduation and how can we develop response strategies to these factors? When taken as a whole they provide a telling story of the current situation and result in the development of support strategies and recommendations.

Paper I – Sowing the seeds of entrepreneurship in North Africa: A United States-Tunisia-Morocco partnership

Submitted to IEEE Spectrum, July 2013

The first manuscript produced as part of this thesis introduces the USTM-TIES program and workshop, discusses the 2013 Moroccan workshop evaluation results, and recounts a case study with the example of Mr. Mohamed El Mouden, an alumnus of the 2012 program who returned in 2013 as a presenter. The purpose of this article was to increase awareness of engineering entrepreneurship and the USTM program among the engineering community and to encourage North African and American scientists and engineers alike to get involved in this line of research.

The results from this article demonstrate the success of the program in spawning interest in engineering entrepreneurship. A total of 67 scientists and engineers, a combination of students, professors, and young professionals, attended the 2013 Moroccan workshops and participated in a series
of lectures, presentations, discussions, and a hands-on design activity. An impressive 64% of participants cited lectures and talks from professors and entrepreneurs as the “event” that inspired them the most. Fourteen percent of respondents reported that the hands-on activity was the most inspiring event; participants reflected positively on the opportunity that the hands-on activity gave them to practice enactive mastery of new creativity, design, and entrepreneurial skills learned during the lectures.

Mr. El Mouden’s story is presented as a demonstration of what short-term entrepreneurial training can accomplish and how the USTM program encourages motivated individuals to pursue enterprise creation. The process of his venture creation is documented, as well as the role that the USTM program played, presenting him as an example of successful early-stage entrepreneur and rounding out the introduction to the USTM-TIES program and its successes. Through the presentation of the benefits of teaching engineers entrepreneurial skillsets and the successes of the USTM-TIES program, this work argues the importance of such programs, encouraging readers to consider involvement in engineering entrepreneurship, particularly in developing nations. Finally, it offers an example of how to support engineering entrepreneurship and to encourage economic growth and job creation in developing regions.

**Paper II – Investigating entrepreneurial motivations and promoting venture creation among engineers and scientists in Morocco**

Submitted to *Entrepreneurship & Regional Development*, July 2013

The objectives of the second manuscript produced as part of this thesis was to investigate what motivates Moroccan engineers to become entrepreneurs and what deters them from it, to evaluate how gender affects entrepreneurial motivation, interest, attitudes, and self-efficacy among engineering students, and to determine if it possible to significantly change participant’s entrepreneurial attitudes, interest, and self-efficacy/entrepreneurial mind-set in a two-day workshop. These objectives were identified because while there has been considerable work on semester- or year-long entrepreneurship and engineering entrepreneurship programs at American universities, there has been little attention given to
shorter programs or presence of such programs in North Africa. In addition, the role of gender was examined in order to clarify existing research as well as to understand whether gender is an important consideration when determining approaches to teaching and encouraging engineering entrepreneurship. In order to address these research questions, a quantitative survey of Moroccan engineering students’ entrepreneurial motivations and deterrents, interest, and self-efficacy was devised, taking advantage of two 2013 Moroccan USTM workshops.

The survey was compiled from existing tools in order to evaluate entrepreneurial motivation, interest/attitudes, and self-efficacy of 55 (27 male, 28 female) Moroccan engineering students. Pre- and post-workshop surveys were analyzed using non-parametric statistics in order to identify the impact of the two-day program on entrepreneurial self-efficacy and interest, and to evaluate motivation and interest and identify gender differences using pre-working survey data. Results found that the workshops were able to significantly increase both entrepreneurial interest and self-efficacy. The results also provided unique insights into the entrepreneurial motivations and gender differences among Moroccan engineers suggesting that the students are motivated to pursue entrepreneurship by push factors and collectivist goals, and consider few obstacles to be significant deterrents to their entrepreneurial aspirations; the primary deterrent identified was lack of capital availability. Men and women largely exhibited the same entrepreneurial interest, self-efficacy, and future career aspirations.

These findings contribute to the limited research on Moroccan entrepreneurship, offering valuable insights into the entrepreneurial motivators and obstacles faced by young engineers, suggesting that, contrary to popular belief, women by and large exhibit the same entrepreneurial interest and self-efficacy as men, and are more likely to be pulled than pushed into venture creation. These findings are particularly significant for universities with tightly packed engineering curricula that would make introducing new courses difficult, suggesting that short courses or workshops may be a viable way to augment existing engineering degree programs. They may also provide the benefit of practicing enactive mastery through the hands-on activities without the pressure of grades looming, allowing for greater self-
efficacy gains than might be expected through a more formal approach. Implications suggest that capital procurement, as the primary challenge, should receive attention in entrepreneurial training and that focusing on social benefits of entrepreneurship may incite interest more than individualistic arguments.

Paper III – The scissor effect: Challenges and response strategies for encouraging Moroccan women to pursue engineering and science careers

Submitted to the Journal of Engineering Education, July 2013

The final manuscript of this thesis was developed to establish what, if any, perceived challenges affect Moroccan women’s interest and ability to pursue science, engineering, and technology (SET) careers and what strategies can be used to overcome these challenges. Specifically, through a combination of focus groups with 30 Moroccan women and supplemental individual interviews we sought to understand connections between participants’ experiences in SET domains, what factors contribute to the reduction of female engineers after college, whether pursuing entrepreneurial activities can offer a respite from perceived gender-based workplace challenges, and how mentoring can be used to encourage women to persevere in the engineering workforce or engineering entrepreneurship. The interview and focus groups were audio-recorded, transcribed, and analyzed using principles of content analysis.

The results from this qualitative study revealed that numerous challenges – including perceived stereotyping, discrimination, tokenism, concerns about work/life balance, and internalized cultural norms – are contributing factors that weigh into women’s decision to pursue (or not pursue) a SET career when they complete their formal education. Entrepreneurship was a strong consideration for several of the participants who indicated that it offers a potential respite from the challenges of working in traditional SET workplaces. Specific benefits of entrepreneurship cited by participants included controlling their daily job activities, defining their own hours, having free time, having a higher earning potential, determining their contribution to society, and better achieving control over life/career balance.
Establishing educational opportunities for women in venture creation and capital procurement may provide additional alternatives for women seeking to employ SET skillsets. Finally, participants expressed a clear need for mentorship – indicating openness to multi-disciplinary and peer mentoring as augmentations to a more traditional mentoring relationship – and indicating that such interactions provide potential as venues to help women face the challenges of employment in SET domains.

**Encouraging engineering entrepreneurship with online resources**

To begin with, the question of how to increase the reach of and participation in engineering entrepreneurship in Morocco was tackled. One of the deliverables for the USTM program is an e-platform where we can disseminate findings to a larger audience. As an alternative to the linear print medium employed in Paper I, the interactivity of online resources was explored as a way to disseminate these findings and increase engineering entrepreneurship interest and involvement and is discussed below.

Research, for all its insights, is of limited usefulness if not shared; as such, it was important that this engineering entrepreneurship research reach the largest audience possible. Despite successful work both in understanding the entrepreneurial motivations of Moroccan engineering students and encouraging them to consider technological innovation and entrepreneurship, the work’s immediate impact was limited largely to its direct audience, the participants of the USTM-TIES workshops.

With hopes of more appropriately sharing findings and increasing the reach of the research, it became clear that the USTM website, restructured with appropriate design and content, could fulfill such a role. The original iteration of the website was perfunctory, including relevant information but warding off visitors with large blocks of text and failing to convey the promise, excitement, and importance of the program and research. In re-designing the website, the first step was to determine who the desired audience was. Due to the international nature of the efforts, it was important to design the site to be accessible to both American and North African viewers. As a Penn State-hosted website and in keeping
with the original design, the default language was kept as English, despite it being the third language, after Arabic and French, for much of the North African audience. Differing cultural use patterns and design preferences were other considerations in the redesign. Zahed, Van Pelt, and Song (2001) argue that both cultural factors and individual characteristics affect website effectiveness, which in turn determines satisfaction. They hypothesize that, “Lengthy text-oriented webpages may not appeal to individuals from [Arabic-speaking] cultures, but they might respond well to the same information punctuated strategically by sound clips and video clips presenting speakers quoting from authorities they know and respect” (Zahed, et al., 2001, p. 86). In keeping with collectivist values of North African cultures (Farid, 2007), Zahed et al. (2001) also suggest that websites that emphasize group unity and interdependence over individual achievements will be more successful. Finally, younger audiences are expected to prefer less text, more visuals, and less overall information (Zahed, et al., 2001). This is particularly relevant since undergraduate engineering students and young professionals represent the target audience and the generation that is still deciding its future career path. University professors are another important demographic for transmitting information and incorporating engineering entrepreneurship into existing education systems, but are expected to be a willing party, open to incorporating new ideas and change.

Another important factor in website design and one which may be susceptible to cultural differences is color. Color serves not only aesthetic functions, but can communicate meaning and influence overall perception and satisfaction of a website (Cyr, Head, & Larios, 2010). Cry, Head, and Larios (2010) examined cultural implications for website design, using eye-tracking to determine whether color aesthetics had any appeal on trust and loyalty. Of the three populations considered – German, Canadian, and Japanese – all disliked the yellow website scheme, although this did not appear to deter gazing times on colored zones. Blue and grey were universally preferred, with no negative comments regarding appeal, appropriateness, or harmony (Cyr, et al., 2010). In the same study, color did show a relationship with satisfaction, which was in turn a predictor of e-loyalty, defined as the loyalty of the
visitor to the online site. This could be of particular importance for USTM-TIES as it seeks to build a relationship with participants. The goal of the website is not only to serve as a one-time information stop, but rather to engage past and future participants and form a network to support engineering entrepreneurship, particularly in North Africa.

Research has found that, “generally, participants across all groups [note] they prefer to have few product details upon first entering a site, and like more details if they chose to investigate the product further” (Cyr, Bonanni, Bowes, & Ilsever, 2005, p. 28; Rosen & Purinton, 2004). Cry et al. (2005) also raise the interesting question of whether the Internet may be evolving into an international common culture. While there are no doubt cultural differences between the United States and North African nations, the findings above, particularly with respect to youth, suggest that the Internet may well be moving towards a shared culture of its own. With this in mind, the goal was to design a website that will appeal to the college-aged population of any culture, be it interdependent or collectivist.

Rosen and Purinton (2004) found that images related to site matter link the complexity of the site to its content, increasing understandability and encouraging exploration. However, they also stress that simplicity of design and ease of navigation are important contributors to overall website preference. They recommend a minimalist homepage design with appropriate eye-catching graphics that will draw the visitor deeper into the site, based off the finding that subjects enjoyed interactive graphics on the homepage of one site that encouraged them to explore further.

Keeping with the “less is more” idea, the homepage has been modified accordingly: see Figure 5-1. Rather than a closed format that is dense with text, there is an open design. An interactive wordle in the shape of Africa greets visitors, with key words linking to related pages. This element exemplifies the recommendation of Rosen and Purinton (2004), providing a central, eye-catching feature and allowing users to engage and encouraging them to explore. With this element, visitors are quickly engaged and the site is able to convey the key concepts and objectives of the USTM-TIES program without forcing surfers to wade through blocks of text. Using direct terms and a less text-intensive design may also prove
friendlier to someone whose native language is not English, an important concern given the target audience. Recent updates and press are featured prominently so that returning visitors can immediately see what is new with the program and website. The description of the organization, its objectives, and mission statement are still presented, but now the user must scroll to see the full text, ensuring that it is readily available, but without cluttering the screen and overwhelming newcomers.

![Figure 1-1. Before and After Homepage Design](image)

Just as important as identifying the target audience is understanding what the objective of the website is. In this case, the website is not only a tool for program descriptions, but also an active recruiting and resource sharing enterprise. Videos and PDFs of workshop lectures and activities are made available for exploration and for professors to incorporate into their own classes. While ideally previous visitors will periodically check the site for new updates, the primary goal is to reach a broad audience and attract potential new participants and partners. Website reach, defined as the number of unique visitors, has been significantly predicted by information content, usability, and ease of navigation (Tarafdar & Zhang, 2008). Indeed, website navigation has been noted as the most important factor across various website domains (Zhang, von Dran, Blake, & Pipithsuksunt, 2000). While navigation relates to formatting and layout, usability is more concerned with ease of use, visual appeal, and fun. In reimagining the USTM website, an attempt was made to update and incorporate both of these principles.

In the original design shared materials were organized by presenter, with small links available
after the biography of each respective speaker. In doing so, prominence was given to the “who” rather than the “what.” While this system may be of interest to participants of previous workshops who are familiar with presenters, it does not offer much value to the exploratory first-time visitor. The redesign opted to organize the shared materials by topic. Each video and PDF file is labeled with a series of keywords related to its content. These files are then sorted into four overarching themes: entrepreneurship, innovation, and creativity. Interested in maintaining a link to those interested in seeking particular speakers, the files are also tagged with the respective speaker and links will still be found with the biographies under the “Scholarly Pursuits” tab. By making the shared materials accessible through multiple avenues, the site becomes easier to navigate for newcomers while maintaining the more relationship-driven aspect that might be sought by workshop alumni.

Although the re-designed website has only just been launched, dramatic increases in traffic and satisfaction from visitors are expected. The reimagined USTM-TIES website now captures the promise and innovative spirit of the program and will expand the possibilities of engineering education in North Africa, connecting with an audience that can ensure continued growth and invigoration of the project.

**Discussion & Contributions**

Engineering entrepreneurship offers a clear outlet for the talents of young engineers while offering the added benefits of economic stability and job creation. This work has investigated the various aspects of encouraging and implementing engineering entrepreneurship in North Africa, specifically Morocco, as a potential means of addressing the high unemployment rate among university graduates (Bensalam, 2012; Fakim, 2012). Each section of this work examines a different view of the subject, including: engineering entrepreneurship program evaluation and reach, the efficacy of short-form educational programs for increasing entrepreneurial self-efficacy and interest, the entrepreneurial
motivations and gender differences of engineering students, and the challenges Moroccan women perceive as they pursue science, engineering, and technology (SET) careers.

The overall contributions of this thesis include: (1) increased awareness of the importance of engineering entrepreneurship, particularly in developing countries such as Morocco, among the engineering community; (2) an effective model of short-term engineering entrepreneurship education that can increase self-efficacy and interest and provide an alternative to traditional university courses; (3) motivational understanding of Moroccan engineers who intend to pursue entrepreneurship, which will allow for targeted encouragement in the future; (4) identification of potential entrepreneurs’ primary concern – capital procurement; and (5) insights into the perceived challenges that Moroccan women face in SET domains and response strategies to encourage their representation in related careers. These findings are explored in further depth in the manuscripts that follow in chapters 2-4.

Conclusions

This thesis demonstrates the importance of engineering education and details methods to increase interest and involvement in entrepreneurship by focusing on the entrepreneurial motivations of Moroccan students, the ability of a two-day workshop to increase entrepreneurial interest and self-efficacy, and the challenges that women face in seeking science, engineering, and technology careers after graduating from college. These findings are used to offer recommendations about how to increase reach, entrepreneurial interest and self-efficacy among engineering students and young professionals, and how to encourage recruitment and retention of Moroccan women in engineering-related professions. Although this research is specific to Moroccan engineering students, results may be applicable to other North African countries and developing nations. Future work should investigate these questions with respect to broader samples to ensure generalizability.
References


Annual Meeting: Education that Works: Invention, Innovation, and Entrepreneurship in Practice, San Jose, California.


UNESCO. (September 2010). Women's and girls' access to and participation in science and technology *Expert group meeting on gender, science and technology* (pp. 1-13). Paris, France: United Nations Division for the Advancement of Women (DAW, part of UN Women).


Chapter 2

Sowing the seeds of entrepreneurship in North Africa: The United States-Tunisia-Morocco partnership

Samantha Adams, Scarlett Miller, Zoubeida Ounaies

Submitted to *IEEE Spectrum*, July 2013

Moroccan engineering student Mohamed El Mouden is standing in front of an audience of 35 students, professors, and business owners in Marrakesh, Morocco describing his journey: how his dreams of innovation and entrepreneurship have evolved from the previous year when he was selected to participate in the United States-Tunisia-Morocco workshop on engineering entrepreneurship and how he has set about bringing his aspirations to life. Through his involvement in the program, El Mouden traveled outside Morocco for the first time and was chosen as a finalist in the USTM business plan competition that helped him successfully secure financial and technological resources to develop his innovative idea. He is a shining example of the potential of young Moroccan engineers, the positive impact the USTM program can have, and how such programs can support economic development in regions such as North Africa; see Figure 2-1.

![Image of 2013 Marrakesh USTM workshop](image1.png)

**Figure 2-1.** 2013 Marrakesh USTM workshop (left) and Mr. El Mouden, preparing to present (right)
The United States-Tunisia-Morocco Technology Innovation and Entrepreneurship Stimulation (USTM-TIES) program was established in 2012 as a joint venture between the Pennsylvania State University, Massachusetts Institute of Technology, and AMIDEAST with the goal of encouraging and enhancing the entrepreneurial potential of young engineers and scientists in order to overcome the deficits of unemployment among the engineering and science graduates in North Africa. Due to its ability to create jobs, entrepreneurship was identified as a potential solution to the problem of economic instability by the USTM program – specifically, technology ventures with high growth potential offer the possibility of economic growth, stabilizing economies and building a foundation for the future – and young North African engineers and scientists represent the perfect demographic with the technological expertise to innovate the next big discovery, provided they acquire the entrepreneurial impetus and training.

Therefore, the USTM-TIES program was developed to aid in the training, engagement and education of young Tunisian and Moroccan scientists and engineers with the goals of: building creative thought processes and innovative design capacities; instilling youth with an entrepreneurial mindset for the commercialization of technological innovations; developing leadership abilities and promote professional skills in young engineering and science students and professionals; establishing networks between university research and the regional business communities to identify appropriate technologies with commercial values; and promoting opportunities for advancement of women in leadership and entrepreneurial activities.

In order to accomplish these goals, USTM-TIES has developed hands-on courses, training sessions, design competitions, and business plan development delivered through a series of two-day workshops held in Morocco and Tunisia in 2012 and 2013. Moroccan and Tunisian engineering students, faculty, and young professionals are selected to participate in these workshops, with activities including educational lectures, guest speakers, and participatory team design projects intended to teach innovation techniques and encourage entrepreneurship. The workshops were developed to encourage creativity, innovation, an engineering entrepreneurship mindset, communication skills, and aid in the development
and commercialization of new technologies. This intersection of activity and research provides pivotal contextual learning and growth within the framework of exploratory design and social entrepreneurship.

Specifically, the USTM-TIES program was created in response to recent events and turmoil in North Africa. Since 2011, Tunisia and Egypt have both seen revolutions and protests became almost daily scenes in Rabat, the capital of Morocco, through the end of 2012 (Crowell, 2013). Even two years later, economic recovery and stability of North Africa remains elusive. Historically, the North African culture favors the stable outlook of a government job; however, government careers are becoming less available and are proving to be unable to accommodate the large quantity of young people graduating from North African universities. Exemplifying trends in the region, the World Bank reports that unemployment among Moroccan youths with a university education is 25% for females and almost 29% for males (Kingdom of Morocco: Promoting youth opportunities and participation, 2012). With significant promise but limited established outlets for their talents, young graduates represent both promise and vulnerability.

The 2013 USTM Moroccan workshops held in Rabat and Marrakesh brought together 67 students, professors, and young professionals. Fifty-five university engineering students (28 female and 27 male) comprised the majority of participants, and a robust collection of potential future innovators. Examples from this year’s lectures include “Engineering Creativity and Innovation” and “Culture: An Important Aspect in the Entrepreneurial Process,” as well as presentations by successful entrepreneurs sharing their experiences. During the hands-on activities, participants were given a chance to apply the concepts they had learned: they were assigned a design problem and were taught how to generate ideas, select concepts, prototype their ideas and to both provide and receive design feedback; see Figure 2-2. The design prompt tackled during the workshops was “developing a low-cost device that dries clothes efficiently with little to no energy consumption for Moroccans,” giving participants a chance to develop a solution to address a practical need in the country.
There has been an overwhelmingly positive response to the program, highlighting useful and inspiring factors. As one civil engineering student expressed, “The hands-on activity was definitely the most useful part of the program since it made me see and realize that I have what it takes to innovate and probably be ready to take a step forward[] in considering a business idea or project.” An open-ended question allowed participants to elaborate on what particularly inspired them, asking, “Do you remember any specific ‘event’ or input during the program that particularly inspired you to consider becoming an entrepreneur?” An impressive 64% cited lectures and talks from professors and entrepreneurs as the “event” that inspired them the most. As one participant noted, “All the speakers and professors who attended the workshop have inspired me to become an entrepreneur; they have made lot of effort to transmit all their experiences and knowledge to [us]… during those two days. I have learned lot of things including how to be more creative and innovative.” Particularly, 18% of respondents from the 2013 Marrakech workshop specifically listed Mr. El Mouden’s presentation. Mr. El Mouden, an alumnus of the inaugural USTM-TIES 2012 workshop, was invited as a speaker to the 2013 Moroccan workshop to present his story. One participant explained that the appeal of Mr. El Mouden’s talk lied in his shared experiences, “[B]ecause he was faced to a several problems the we can face[] too.” While stories of entrepreneurial efforts, failures, and successes were inspiring on the whole, Mr. El Mouden’s experience seemed particularly valuable, his personal experiences resonating strongly. For students, he represents what they themselves can accomplish in the future – having experienced similar circumstances,
education, background and resources. In the words of one participant, “all we need is that first push, to say I'm here, I can do it, nobody can stop me.”

Talking with Mr. El Mouden, his enthusiasm for engineering entrepreneurship quickly reveals itself. He does not hide that his entrepreneurial aspirations have a long history: first imagining a cheese factory, and then moving on to a new idea when his young cousin became sick after missing out on important immunity proteins in breast milk. Driven by the desire to help, he came up with the idea of creating a product that would bolster children’s immunity systems. Observing that children love yogurt, his original plan was to produce a yogurt that contained 6% breast milk instead of 100% cow milk. It was at this time in the process that Mr. El Mouden attended the inaugural USTM workshop, where he had the opportunity to refine his idea. He was asked to complete a marketing study, at which point he received feedback that others viewed his idea as incompatible with Islamic and cultural teachings. Recognizing this weakness and the problems it might pose in market reception, he continued to look for new approaches to the problem.

In the laboratory, with the help of a professor in his internship company, he came up with a solution: add immunoglobulin, reduce the fats, add two types of vitamins, and reduce the indigestible proteins. In his redesign, he also discovered that children are not enthusiastic about the smell of yogurt and decided to add a candy scent. Despite receiving help from his university and internship company, he highlights the support of the USTM program as being particularly beneficial. When asked about his choice to return to the program as a presenter, he asks:

“Have you ever been to an adventure? An adventure where you learned so many things, had so much fun and you [met] so many new and nice people? Wouldn’t you [come] back and tell your friends and all the people how good [it] was? [It was] exactly the same for me. [The] USTM experience was the most beautiful experience in my life. I [felt] like a great businessman and a good leader and I wanted to pass my experience to everybody [in] USTM… I wanted to give them hope and to tell them everything is possible.”
Emboldened by his enthusiastic reception, Mr. El Mouden looks forward to returning to future USTM workshops as owner of his own company, fulfilling his dream of helping both his country and the younger generations of engineers and scientists. In his own words: “Through my experience here in Morocco I [never had] someone who believes in me as they did. When I talked to everyone else they said that the project won’t succeed and I will have so many problems; but the first word[s] that [a USTM leader] said [was] “you can do it.”” Passion and hard work like Mr. El Mouden’s reaffirm the possibilities of engineering entrepreneurship and offer it a warm reception in Morocco. Continuing its work, USTM-TIES will train its next generation of engineers and scientists in technological venture creation this fall in Sfax, Tunisia. If enthusiastic responses to date and experiences such as Mr. El Mouden are any indication, the future holds great promise for the USTM-TIES program and its ability to inspire and support engineering entrepreneurship in North Africa.
References


Chapter 3

Investigating entrepreneurial motivations and promoting venture creation among engineers and scientists in Morocco

Samantha Adams\(^a\), Scarlett Miller\(^b\), Zoubeida Ounaies\(^c\)

\(^a\) Department of Industrial Engineering, \(^b\) School of Engineering Design, \(^c\) Department of Mechanical Engineering, The Pennsylvania State University, University Park, United States

\(^a\) spa129@psu.edu, 359 Leonhard Building, University Park, 16802; \(^b\) scarlettmiller@psu.edu, (814) 863-4143, 213-P Hammond Building, University Park, 16802; \(^c\) zxo100@psu.edu, (814) 867-4443, 157B Hammond Building, University Park, 16802

*Submitted to *Entrepreneurship and Regional Development*, July 2013
Abstract

The need for educating students who are interested in engineering entrepreneurship and have the skillset to pursue it is great in developing countries like Morocco that suffer from high unemployment of university graduates. However, tightly packed engineering curricula make introducing new courses on entrepreneurship difficult. The purpose of this study is to understand engineers’ motivations for pursuing entrepreneurship in Morocco, examine gender differences, introduce our two-day approach to teaching entrepreneurship, and assess how a short-term program impacts entrepreneurial interest and self-efficacy. Fifty-five Moroccan students participated in a two-day workshop held in two Moroccan cities. Pre- and post- workshop surveys on entrepreneurial motivation, interest, and self-efficacy were used to measure workshop effects, motivations, and existing gender differences. The statistical results of the survey data demonstrate that short-form workshops can significantly increase engineering entrepreneurship interest and self-efficacy. Findings also reveal that men and women exhibit similar entrepreneurial interest and self-efficacy, and suggest that Moroccan engineers are primarily motivated into entrepreneurship by pull factors and collectivist goals, while they consider lack of capital to be the primary challenge to entrepreneurship. This study contributes to the limited research on Moroccan entrepreneurship, offering valuable insights into the entrepreneurial motivators and obstacles faced by young engineers.

Keywords: engineering entrepreneurship, Morocco, entrepreneurial self-efficacy, entrepreneurial motivation, gender, entrepreneurship education

Introduction

Since 2011 a number of North African nations have experienced civil unrest, including riots and protests in Morocco (Bensalam, 2012; Fakim, 2012) and revolutions in both Egypt (Kirkpatrick, 2011a) and Tunisia in 2011 (Kirkpatrick, 2011b). Much of this tension relates to the high un- and under-employment
rates in North African countries (Bensalam, 2012). One of the largest sources of this unemployment are recent college graduates who often look to government positions post-graduation due their perceived stability (Fakim, 2012). While these government positions are alluring, there are far fewer positions available than students graduating, creating a problematic imbalance that contributes to soaring unemployment rates. In addition, those who are lucky enough to find a position are often hired with only a short-term contract due to Labour Code restrictions regarding layoffs of employees with indefinite contracts (Gray & Amine, 2002). Entrepreneurship, particularly the high-growth potential of technology venturing, represents a possible solution to such problems. As such, it warrants research both in how to integrate entrepreneurship education in North African universities as well as how to promote entrepreneurial interest among college students in the region. Although Moroccan engineering students may be interested in learning about entrepreneurship, universities often face already packed and rigid engineering curricula. This challenge leads to the question of whether or not short-term programs such as workshops are able to provide many of the same benefits of semester-long courses without the associated time constraints.

Specifically, the need to explore this problem in Morocco is important due to high-running civil tensions in the country (Fakim, 2012). The economic benefits of entrepreneurship, both growth and development, are readily acknowledged: entrepreneurship lays the foundation of new industries, creates jobs and wealth, and results in social adjustment (Jack & Anderson, 1999; Refaat, 2009). However, despite governmental incentives in Morocco, the lack of mechanisms for university-government-industry cooperation has limited the capability of taking advantage of research outcomes to develop new businesses or contribute to industrial growth. In addition, North African countries have an admitted dearth of product development and innovation (Patel, June 2011).

Therefore the United States, Tunisia, Morocco Technology Innovation and Entrepreneurship Stimulation (USTM-TIES) program was created to test the utility and impact of short-term entrepreneurship training programs and their influence on entrepreneurial intent in Morocco. Specifically, USTM-TIES is focused on the training, engagement and education of young Tunisian and Moroccan
scientists and engineers through hands-on courses, training workshops, design competitions, and business plan development. In late March 2013, two workshops, created as a concise introduction to creativity, innovation, and the entrepreneurial mindset, were held in Morocco. Each workshop took place in a major Moroccan city and was two days in length, involving a mixture of lectures, discussions, and hands-on activities. Designed to bring together students, academics, and young professionals, the workshops represented a fertile ground not only for interest and self-efficacy assessments, but also to investigate the existing patterns of engineering entrepreneurship in Morocco. While the focus of the program is ambitious and some goals not easily measured, there is a need to understand the particulars of entrepreneurial interest and self-efficacy: what motivates and deters young engineers from pursuing entrepreneurship? Do demographic and gender characteristics play a role? Is it possible to incite entrepreneurial interest and intentions during short programs?

Hence, the objective of this study is to introduce our two-day approach to teaching engineering entrepreneurship, our evaluation of whether or not entrepreneurial attitudes, interest, and self-efficacy can be significantly increased in such a limited time frame, and our recommendations for implementing successful short-term programs in the future. A secondary, yet equally important, aim is to reveal information about the current situation of engineering entrepreneurship in Morocco, offering crucial insights into entrepreneurial motivations, obstacles, and gender differences, building upon the limited research on the subject. While this study specifically addresses innovation and entrepreneurial education in Morocco, it is our hope that the model and the conclusions will be applicable in other developing countries that lack a strong entrepreneurial foundation in order to encourage economic stability and provide an appropriate outlet for the talents of young engineers.
Background

Entrepreneurship in North Africa

Rising tensions and high unemployment rates, particularly among the educated, in Morocco (Bensalam, 2012; Fakim, 2012) have led the research community to focus attention on entrepreneurship in the country and, more broadly, North Africa. Most research in this space, however, has only pointed to cultural and gender differences in entrepreneurial experience rather than focusing on entrepreneurial intent and ways to promote entrepreneurship in science and engineering. This is problematic because it does not address the social responsibility of the field to support economic stability through active encouragement of entrepreneurship. Therefore, while the research conducted to date does provide us with preliminary insights into gender differences and how North African nations relate to broader entrepreneurial trends, it lacks details on how to promote economic growth in the region through entrepreneurial efforts.

What we do know is there are many differences between North American and North African entrepreneurial interests and motivation. For example, Farid (2007) found that Egyptians are less likely than Americans to display individual entrepreneurial traits and are more likely to have an external locus of control. This research suggests that such differences can be related back to the more collectivist nature of Muslim cultures, as opposed to the individualistic American culture. In groundwork research on entrepreneurship in Morocco, Gray, Foster, and Howard (2006) interviewed 201 Moroccan entrepreneurs and found innovation and risk taking to be low in the sample, but a high desire for independence and achievement to be common; this may be attributed to failure being judged harshly and with severe consequences in Morocco. In comparison, the US commonly views failure as an important, and almost expected, learning experience in entrepreneurship (Gray, et al., 2006), which indicates that North Africans may be more risk averse than North Americans (Farid, 2007). These studies highlight the many differences between North African and American cultures and bring to question whether results from
research on entrepreneurship in the US are generalizable to North African cultures such as Morocco, creating a need for context-specific findings.

In addition to studying cultural differences, there has also been research on the impact of gender on entrepreneurship in North Africa (Gray & Finley-Hervey, 2005; Harbi, Anderson, & Mansour, 2009). While no significant differences in men and women’s reports of financial resource or information availability in Tunisia have been found, a statistical difference between their ratings of feasibility and their attitude toward beginning a business have been identified, with men being favoured (Harbi, et al., 2009). For example, there are two different ways individuals can enter into entrepreneurship: people can either be pulled or pushed. Being pulled into entrepreneurship implies that individuals are attracted to business venturing for reasons such as wishing to pursue a product idea, a desire for flexibility, control, or the desire to make money. On the other hand, being pushed refers to entering into entrepreneurship out of economic need, unemployment, or dissatisfaction with the status quo (Gray & Finley-Hervey, 2005; Gray, et al., 2006). A study on gender differences in entrepreneurship in Morocco found that women were pushed into venture creation at a significantly higher rate than men (Gray, et al., 2006). Finally, although not studied in Morocco, there has been research that shows that men typically exhibit higher entrepreneurial intentions than women (Wilson, et al., 2007; Zhao, et al., 2005). Mixed results have been found on the effects of gender on entrepreneurial self-efficacy: Zhao, Seibert, and Hills (2005) noted no significant relation between gender and entrepreneurial self-efficacy, whereas Wilson, Kickul, and Marlino (2007) found that men exhibited higher entrepreneurial self-efficacy among both high school and MBA populations. Women have also been shown to demonstrate lower engineering self-efficacy (W. A. Lucas, Cooper, Ward, & Cave, 2009).

Given the limited amount of research on entrepreneurship in Morocco, it is crucial to confirm or refute existing findings regarding gender differences and entrepreneurial characteristics in order to appropriately address and encourage technology venture creation and economic stability. In addition, entrepreneurial motivators, deterrents, and individual characteristics such as self-efficacy in the region
have received little attention. Therefore, the current study was developed to respond to these research gaps.

**Teaching engineering entrepreneurship**

One of the biggest challenges in promoting entrepreneurship is developing methods to effectively teach entrepreneurial skill sets and understanding what motivates individuals to pursue entrepreneurship. This challenge is compounded by the fact that entrepreneurship lacks a strong theoretical foundation or methodology (Fiet, 2000). This theoretical void has resulted in various approaches to entrepreneurial education, which can vary greatly in content and strategies – some of which stress practice while others emphasize theory. While a particular “correct” approach to teaching entrepreneurship remains uncertain, many universities have created entrepreneurship courses, programs and undergraduate minors/majors to support entrepreneurship through undergraduate curricula.

In particular, engineering entrepreneurship has grown as a distinct sub-discipline and universities have begun to incorporate entrepreneurship-focused courses into engineering education (Bilen, et al., 2005; Creed, et al., 2002; Ohland, et al., 2004; Standish–Kuon & Rice, 2002; Wang & Kleppe, 2001). The goal of these courses and programs is to create “a new type of engineer, an *entrepreneurial engineer*, who needs a broad range of skills and knowledge above and beyond a strong science and engineering background” (Creed, et al., 2002, p. 185). These courses have been shown to have a positive impact on student perception of their ideation ability (Bilen, et al., 2005), greater use and understanding of creativity and problem-solving strategies (Dabbagh & Menascé, 2006), and increased comfort working in interdisciplinary teams (Wang & Kleppe, 2001). Dabbagh and Menascé (2006) have also explored engineering entrepreneurship as a way to motivate students, increase interest in engineering, and to offer an example of what students will experience as engineers in the real world.

While a need for entrepreneurial focus in North Africa has been identified (Refaat, 2009), it was only recently that North African universities began to teach entrepreneurship in undergraduate
institutions. For example, in 2010 the Tunisian Ministry of Education and Higher Education began offering an application-based entrepreneurship track for senior undergraduates. It was found that students who participated in the entrepreneurship track were 3% to 5% more likely to be self-employed one year after graduation compared to the control group that only exhibited a 4.4% rate of self-employment (Premand, Brodmann, Almeida, Grun, & Barouni, 2012). While the effectiveness of this program can be questioned, it was also found that those who participated in the entrepreneurship track reported a more optimistic outlook about the future (Premand, et al., 2012).

Although university entrepreneurship programs throughout the world have exhibited success, many schools face the problem of time and course credit constraints as they try to incorporate entrepreneurship into engineering education; there are difficulties not only coordinating between departments, but also trying to fit additional courses into already tightly-packed engineering curricula (Nichols & Armstrong, 2003; Rayess, Weaver, & Kleinke, 2010). It has been suggested that educational programs raise entrepreneurial intentions and attitudes primarily through inspiration, as opposed to learning or resource availability (Souitaris, Zerbinati, & Al-Laham, 2007). Such findings suggest that short-form courses and workshops could be effective in piquing students’ interest in entrepreneurship.

Although there is a clear need for abbreviated options to semester or year-long courses, few research studies have explored viable alternatives. For example, while single-lecture mini-case studies with the use of videos have been attempted as a method for teaching entrepreneurial thinking to engineers in a time-efficient manner, they have not been evaluated for their effectiveness (Rayess, et al., 2010). However, a recently developed program, the Cambridge-MIT Institute’s (CMI) Enterprisers residential program, was able to show that both entrepreneurial self-efficacy and intentions could be significantly increased in just a week, with self-efficacy effects lasting at least six months into the future (Cooper & Lucas, 2006; W. Lucas & Cooper, 2004). With the exception of mini-courses and the CMI’s Enterprisers program however, little research has attended to short-form entrepreneurial education. Therefore, the current study was developed to test the effectiveness of a new model of teaching entrepreneurship in the form of a two-day technological innovation and entrepreneurship education workshop, which includes a
self-efficacy evaluation. If successful, this new teaching method will provide a valuable alternative to institutions that wish to introduce engineering entrepreneurship to inspire students without curricular time to devote to full courses.

**Assessing entrepreneurship and entrepreneurial intent**

One of the most important aspects of starting any new entrepreneurial program is developing and using effective assessment techniques. In other words, how can we ascertain if we have influenced the entrepreneurial intent or self-efficacy of a participant in a workshop, course, or program? The time to complete the assessment is also important; particularly in short programs where there is limited time to both teach and evaluate individual achievements. In recent years there has been a drastic increase in the focus on entrepreneurship assessment methods, particularly as they relate to engineering and technology. Assessment methods in this area tend to fall into three groups: course evaluations, focused instrument evaluations, and total program evaluations (Duval-Couetil, et al., 2010).

Much of the scholarly work has revolved around focused assessment instruments intended to measure specific aspects of entrepreneurship, particularly entrepreneurial self-efficacy (Borchers & Park, 2010; Chen, et al., 1998; McGee, Peterson, Mueller, & Sequeira, 2009; Zhao, et al., 2005). Self-efficacy affects what tasks people choose to pursue and the perseverance they have in the face of obstacles; individuals who believe they are capable are more likely to set challenging goals and increase their efforts in the face of failures (Bandura, 1997). In comparison to locus of control and other broad personality-based tests, entrepreneurial self-efficacy is narrower in scope, considering only behaviour and allowing for predictability in specific situations and events (Chen, et al., 1998; McGee, et al., 2009).

Entrepreneurial self-efficacy is a promising tool, providing specificity and the ability to examine multiple dimensions of entrepreneurship; it has undergone several iterations and has been incorporated into a number of broader measures.
In addition to measures of self-efficacy, Shartrand and Weilerstein et al. (2008) created two different assessment approaches, the 105-item National Collegiate Inventors and Innovators Alliance (NCIIA) Entrepreneurship Inventory with focus on terms and concepts and the Entrepreneurial Mindset Rubric, a case-study-based open-ended response test intended to measure entrepreneurial thinking skills. While the Entrepreneurial Mindset Rubric evaluation is promising, intensive time input for its administration and related language concerns (English was the third language of most workshop participants) renders its use difficult in this context. The broad scope of the NCIIA Entrepreneurship Inventory, with significant focus on finance, accounting, and traditional business skills, fails to capture the goals of the workshop. More recently, Duval-Couetil et al. created the Engineering Entrepreneurship Survey (EES), a broad program assessment with questions grouped around several areas, including: attitudes and awareness, behaviours, knowledge and skills, self-efficacy, and demographic and background data (Duval-Couetil, et al., 2010; Duval-Couetil, Reed-Rhoads, & Haghighi, 2011). The EES was built with Cooper and Lucas’ (2006) survey model as a foundation, incorporating key self-confidence evaluation items. With a specific engineering perspective and a wide range of knowledge-types addressed, many of the items of the Engineering Entrepreneurship Survey were appropriate for the USTM-TIES workshop.

While there are numerous entrepreneurial assessments that have been created, the heavy focus on finance and business skills incorporated into most of them is inconsistent with our educational theory. Completion time and language concerns are also important consideration when selecting an appropriate evaluation strategy, rendering lengthy questionnaires or essay responses impractical for short-term programs. While Duval-Couetil et al. (2011) appropriately captured the essence of engineering entrepreneurship, their tool fails to address push motivations or fully explore entrepreneurial mind-set through self-efficacy and attitude evaluations. This study seeks to address these deficits by developing a new assessment strategy that leverages prior work in engineering entrepreneurship evaluations. Therefore, this work adds to the knowledge base by developing and testing the utility of the assessment tools for short-term programs.
Summary and research questions

The literature suggests that entrepreneurial self-efficacy can be positively impacted by formal education and is key to entrepreneurial learning, as well as exhibiting a positive correlation with intent to start a business (Borchers & Park, 2010; Chen, et al., 1998; W. Lucas & Cooper, 2004; Zhao, et al., 2005). With this evidence, the authors firmly believe it possible to facilitate significant increases in interest, attitudes, and self-efficacy through a two-day workshop. Moroccan entrepreneurs report being largely drawn into entrepreneurship by opportunity factors, although, as suggested by Farid (2007), the specific motivations for pursuing or avoiding entrepreneurship may be culturally determined and differ from reasons commonly cited in the U.S.

Although some research has indicated no differences between the entrepreneurial potential of men and women other than risk-taking acceptance (Zeffane, 2013), and reviews of North African female entrepreneurship have yielded mixed findings (Gray & Finley-Hervey, 2005; Gray, et al., 2006; Hattab, 2012a), the overall literature suggests that women will exhibit lower entrepreneurial intentions and possibly lower self-efficacy (Chen, et al., 1998; Harbi, et al., 2009; Zhao, et al., 2005). Therefore, through this research the authors sought to address the following questions:

1. What motivates Moroccan engineers to become entrepreneurs? What deters them?
2. How does gender affect entrepreneurial motivation, interest, attitudes, and self-efficacy among engineering students?
3. Is it possible to significantly change participant’s entrepreneurial attitudes, interest, and self-efficacy/entrepreneurial mind-set in a two-day workshop?

Methodology

In order to address these research questions, Moroccan engineering students and young professionals were recruited to attend one of two two-day workshops intended to increase innovation capacities and
instil an entrepreneurial mind-set. Surveys were used to investigate entrepreneurial motivations, the relation of demographics to self-efficacy and interest, and whether the workshop was successful in increasing the entrepreneurial mind-set of participants. While both students and young professionals were recruited for participation, this study reports only the findings from the student participants due to its focus on promoting recent graduates to pursue entrepreneurial activities post-graduation.

Participants

Prior to the workshop, Moroccan university engineering students were recruited for a two-day workshop on entrepreneurship by the non-government organization AMIDEAST/Morocco through promotional material targeted at two distinguished Moroccan universities that focus on engineering and science education. Interested students submitted applications for the workshops and were assessed by AMIDEAST/Morocco based on the following criteria: English proficiency, degree of motivation, and academic ranking. A total of 55 students (27 male, 28 female) participated in the workshops. Forty-four participants were between the ages of 18 and 22, and 11 between the ages of 23 and 27.

It should be noted that students were from two of the most elite engineering institutions in the country and that there are only approximately 9,000 undergraduate students in Morocco (Statistiques Universitaires 2010-2011, 2011). Compared to the roughly 472,000 engineering students in the United States (Yoder, 2012), an appropriately selected sample of 55 Moroccan students is arguably able to provide meaningful insights into the research population. Since our target population was driven by Moroccan engineering students who are most likely to pursue entrepreneurship, this further limits the scale of the population, increasing the representativeness of the sample employed.

Workshop details and assessment methods

In order to understand current motivation for pursuing entrepreneurship and the usefulness of short
programs for stimulating entrepreneurial self-efficacy and interest, a workshop was developed to promote technology innovation and commercialization strategies in engineering and science. This workshop was held twice in March 2013, in two major Moroccan cities. The specific goals of the workshops included: building creative thought processes and innovative design capacities, instilling an entrepreneurial mindset for the commercialization of technological innovations, developing leadership abilities and promoting professional skills in young engineering and science students and professionals, establishing networks between university research and the regional business communities to identify appropriate technologies with commercial values, and promoting opportunities for advancement of Moroccan women in leadership and entrepreneurial activities.

Each workshop lasted a day and a half and the content was broken into a half-day of lectures on entrepreneurial topics, taught by faculty from two large American northeastern universities and the two Moroccan universities, and a day of hands-on activities. Specifically, during the hands-on activities student participants were given a design problem and were taught how to generate ideas, select concepts, prototype their ideas, and give/provide design feedback. The design problem considered during the workshops was, “Developing a low-cost device that dries clothes efficiently with little to no energy consumption for Moroccans;” Figure 1 shows participants interacting during the hands-on sessions. A comprehensive list of workshop activities and scheduling can be found at www.engr.psu.edu/ustm/.

Figure 3-1: Brainstorming session (left) and prototyping session (right) for hands on design activity during one of the two workshops
In order to investigate the research questions, three surveys were developed to assess entrepreneurial motivation, interest/attitudes, and self-efficacy. Specifically, at the beginning of each workshop participants were informed of the purpose of the assessment and the research being conducted. Once consent for participation was obtained, participants were asked to complete a demographic questionnaire that included questions about their gender, age range, occupation, and academic major. Each participant was given a randomly assigned subject number that was used to ensure anonymity during the study. After completing the demographic survey, workshop leaders administered the pre-survey, which was developed to assess individual entrepreneurial motivation, self-efficacy, and attitudes/interest in entrepreneurship. At the end of the workshop, participants were asked to answer the same survey items as the pre-survey, with the addition of seven questions related to perceptions of the workshop and its leaders. All surveys were administered on paper to ensure an adequate return rate. The three surveys used in this study can be found in the Appendix.

**Survey design**

In order to evaluate whether the specific workshop goals delineated above were met, researchers opted to develop a survey that investigated entrepreneurial mind-set, described as a unique combination of communication skills, teamwork, leadership and management, ideation, and the ability to recognize and act on market openings. Most of the current surveys developed to test these attributes fail to capture the specific engineering mind-set and focus heavily upon knowledge of business skills, an area of less concern to this study. Therefore, in order to measure the effectiveness of the workshop at promoting engineering entrepreneurship skills and mind-set, survey items were compiled from a number of validated scholarly assessments developed to evaluate the effectiveness of programs in meeting desired needs.

The compiled survey focused on three areas of interest: motivation, attitudes/interest, and self-efficacy; see Tables 1, 2, and 3 for complete question breakdown. The post-workshop survey included the same items as the pre-survey, with the addition of 13 items geared specifically towards programmatic
evaluation for future improvements; see Appendix for details. Questions on the surveys were derived from Duval-Couteil et al.’s (2011) Engineering Entrepreneurship Survey, McGee et al.’s (2009) Entrepreneurship Self-Efficacy survey, and Humanitarian Engineering and Social Entrepreneurship (HESE) survey, Gray et al.’s (2006) findings on Moroccan entrepreneurship, and the 2012 workshop evaluation (2012 USTM Workshop Survey Results); Tables 2 and 3 provide a key identifying the source of each item. These sources were used because they had been tested for reliability and validity in prior studies. In particular 60% of the survey items (Q1–6, 8 and 10) were adapted from Duval-Couteil et al. (2011), which was previously tested for reliability with a Cronbach’s Coefficient Alpha of at least .83. In addition, 12% of the survey (Q9 and 7) was adapted from McGee et al (2009), which was previously tested for reliability with a Cronbach’s Coefficient Alpha of at least .80. The survey also went through an iterative design to test for language concerns with North African graduate students at The Pennsylvania State University in an effort to identify any items that were unclear or could be easily misinterpreted. For consistency, all closed-ended questions used a 5-point Likert scale, with appropriately anchored endpoints.

Each survey took approximately 30 minutes to complete. It should be noted that while the participants were fluent English speakers, it was not their first language and thus it took them longer to complete the evaluation than a native English speaker.

Analysis and results

In service of our research goals, the pre- and post- surveys were matched using the unique participant IDs and statistical tests were conducted to address each research question. Due to the anchored ends of the pre- and post-survey, the 5-point Likert scale results were treated as ordinal data; analysis was conducted with non-parametric tests because equal intervals cannot be assumed between values, therefore rendering use of means inappropriate (Gardner & Martin, 2007; Jamieson, 2004). The null hypothesis for the single-sample tests was that the median is equal to the midpoint of the scale (3) and for the multi-sample test the
hypothesis was that the median was the same across groups. Note, a median is utilized instead of a mean due to non-parametric statistics. In addition, since multiple statistical tests are performed on the 87 scaled survey items, the Bonferroni correction is applied to maintain a family wise error rate of 0.05 (Abdi, 2007). Therefore, the level of significance used in this study is 0.017. The following sections summarize the analysis performed using SPSS v. 16 on the 55 student responses, presented with relation to our research questions.

**What motivates Moroccan engineers to become entrepreneurs? What deters them?**

In order to analyse entrepreneurial motivations of the student participants, the pre-survey was evaluated to understand entrepreneurial interests prior to attending the workshop. Specifically, we were interested in the push and pull factors associated with entrepreneurial interest. In order to understand this, a single-sample Wilcoxon sign rank test with the null hypothesis of a neutral median of 3 (mid-point of Likert scale) was used to analyse Question 1, which related to entrepreneurship motivators, and Question 3, which related to deterrents to entrepreneurship. Percentages of push and pull factors were also calculated based on the number of supporting factors and the total number of push or pull factors, respectively. The results revealed several significant findings, found in Table 1.

The analysis revealed that 14 of the 19 motivation items in Question 1 and 7 of the 14 deterrent items of Question 3 were statistically significant. Notably, five items (have more free time, follow a family tradition, lack of satisfaction with current job, badly needs money, and irregular income) had medians less than 3, indicating that such factors are not motivators for pursuing entrepreneurship for this sample. It is interesting to note that three of these items are considered ‘push’ factors. The results of the analysis of Question 3 show that only “Lack of/difficulty in getting initial capital for start-up” ($mdn = 4$) had a median greater than 3, meaning participants felt that this would deter them from entering entrepreneurship. Six items had medians below 3, including “Fear of failure” and “Doubts about personal abilities.”
Open-ended Questions 2 and 4 were evaluated qualitatively, offering explanation of the statistical results found in Questions 1 and 3, respectively. Two primary themes emerged from the answers, supporting the statistical findings: the desire for personal development and achievement, and a desire to help one’s country and effect change in society. Although Question 2 was optional, 11 participants made mention of helping their country, and 8 cited a desire for personal development. Exemplifying this trend, participant 81 responded that they want to “achieve personal development and make positive change in an economic and social way,” and participant 113, “To be a model for young students in order to innovate and create new concepts, technology; to get the chance to work with active citizen as co-workers or partners; to be a part of the technology's development in my country.” Although there were only nine responses in total to Question 4, the participants who did answer cited gathering capital as a primary concern, offering support to the statistical results. Participant 58 noted, “I would not start a business due to lack of support from business promoters and investors mainly because of my young age and lack of experience,” while participant 121 noted, “The only reason which can stop me from creating my own business is the total lack of finance or political problems.”

From these findings, we can conclude that the participants do not view time input, fear of failure, personal ability, or irregular income as barriers that would stop them from starting a business. Of the pull factors, 56.25% received positive support as motivators, 31.25% were neutral, and participants disagreed with 12.5%. One hundred per cent of the push factors had medians lower than 3, suggesting that they are not strong motivators. These results suggest that the Moroccan participants in our study are being pulled into entrepreneurship.
Table 1. What Factors are Significant Entrepreneurship Motivators or Deterrents (Median ± 3)?

<table>
<thead>
<tr>
<th>Question</th>
<th>Motivation</th>
<th>Median (Pre)</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Why would you start a business due to / in order to...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Focus on a technology that interests me *</td>
<td>4</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>b. Satisfy a need in a market *</td>
<td>5</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>c. Solve a social problem *</td>
<td>4</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>d. Create something of my own *</td>
<td>5</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>e. Have more flexibility and independence *</td>
<td>4</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>f. Have more free time *</td>
<td>2</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>g. Make more money *</td>
<td>4</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>h. Be at the head of an organization *</td>
<td>4</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>i. Manage people *</td>
<td>4</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>j. Create jobs *</td>
<td>5</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>k. Follow a family tradition *</td>
<td>1</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>l. Gain high social status *</td>
<td>3</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>m. No job prospect *</td>
<td>2</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>n. Frustration of lack of satisfaction with current work/job *</td>
<td>2</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>o. Badly needs money *</td>
<td>1</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>p. Great market opportunity *</td>
<td>4</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>q. Previous work experience *</td>
<td>3</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td>r. Observed success of others *</td>
<td>4</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>s. Being approached by a potential partner *</td>
<td>3</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Q3. I would NOT start a business due to...</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Lack of ideas regarding what business to start</td>
<td>3</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>b. Lack of assistance available to assess business viability</td>
<td>3.5</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>c. Excessive risk</td>
<td>2</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>d. Lack of / difficulty in getting initial capital for start-up</td>
<td>4</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>e. Lack of legal assistance or counseling</td>
<td>3</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>f. Lack of knowledge of the business world and the market</td>
<td>4</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>g. Lack of experience in management and finance</td>
<td>4</td>
<td>0.44</td>
<td></td>
</tr>
<tr>
<td>h. Current economic situation</td>
<td>3</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>i. Irregular income</td>
<td>2</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>j. Lack of support from people around me (family, friends, etc.)</td>
<td>1</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>k. Fear of failure</td>
<td>1</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>l. Doubts about personal abilities</td>
<td>1.5</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>m. Having to work too many hours</td>
<td>1</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>n. Problems with employees and colleagues</td>
<td>2</td>
<td>&lt;0.001</td>
<td></td>
</tr>
</tbody>
</table>

+ denotes pull factors; - denotes push factors

Table 1. What factors are significant entrepreneurship motivators or deterrents?
How does gender affect entrepreneurial motivation, interest, attitudes, and self-efficacy of engineering students?

In consideration of how gender relates to entrepreneurial motivation, deterrents, and future career plans, a Mann-Whitney U test was conducted on the pre-survey responses for Questions 1, 3, and 5 to compare male (N = 27) and female (N = 28) responses: see Table 2. Our analysis revealed several interesting findings.

First, our results revealed that three items of Question 1, which related to entrepreneurial motivation, were statistically different between males and females. In particular, males were more likely than women to enter entrepreneurship to: “make more money”, due to “no job prospect”, and “badly needs money”. Since two of these three items are ‘push’ factors into entrepreneurship, these results suggest that men may be slightly more likely to be pushed into entrepreneurship than women. Males also had a higher level of agreement for two items of Question 3: “having to work too many hours”, and “problems with employees and colleagues,” which means these items discourage their pull into entrepreneurship.

In addition, our analysis of Questions 7 through 11, which focused on the difference between men and women’s attitude/interest and self-efficacy, revealed one statistical difference: women (mdn = 5) expressed more “interest in taking entrepreneurship classes” (male mdn = 5), U = 254.5, p = 0.015. Overall, men and women expressed similar levels of engagement in entrepreneurship, although the one detected differences indicates that women may exhibit slightly more interest in entrepreneurship learning.

There were no significant male/female differences about future plans and career intention (Question 5). The only item that even approached significance (p = 0.07) was “pursue unpaid work (household responsibilities, volunteering, child rearing, etc.),” although it is important to note that it still had an unfavourable ranking for both genders. The median ranking of each item was also determined for men and women to look for suggestions of gender differences. The rankings reveal that the top four choices, although ranked differently, were the same for men and women: “work for a medium or large-
size business” (men $mdn = 2.5$, women $mdn = 3$), “start my own business or be self-employed” ($mdn = 2$
for both men and women), “work for a small business or start-up company” (men $mdn = 3$, women $mdn =$
4), and “attend graduate/professional school” ($mdn = 3$ for both genders). Therefore, in this sample, there
is no evidence that men and women exhibit different career intentions. Overall, these findings suggest
that there are minimal gender differences in motivation and interest, and none in future plans or self-
efficacy.
Table 2. Do Motivation, Deterrents, or Future Plans Differ Between Men and Women?

<table>
<thead>
<tr>
<th>Question</th>
<th>Motivation</th>
<th>Male Median</th>
<th>Female Median</th>
<th>Mann-Whitney U</th>
<th>p-Value</th>
<th>Adapted From</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q1. Why would you start a business due to / in order to...</strong> (1 = Strongly Disagree, 5 = Strongly Agree)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Focus on a technology that interests me*</td>
<td>4</td>
<td>4</td>
<td>292</td>
<td></td>
<td>0.38</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>b. Satisfy a need in a market*</td>
<td>5</td>
<td>5</td>
<td>298</td>
<td></td>
<td>0.31</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>c. Solve a social problem*</td>
<td>4.5</td>
<td>4</td>
<td>342.5</td>
<td></td>
<td>0.87</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>d. Create something of my own*</td>
<td>4</td>
<td>5</td>
<td>274</td>
<td></td>
<td>0.29</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>e. Have more flexibility and independence*</td>
<td>4</td>
<td>5</td>
<td>309.5</td>
<td></td>
<td>0.33</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>f. Have more free time*</td>
<td>2</td>
<td>1.5</td>
<td>247.5</td>
<td></td>
<td>0.08</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>g. Make more money*</td>
<td>4</td>
<td>3</td>
<td>205</td>
<td></td>
<td>0.01**</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>h. Be at the head of an organization*</td>
<td>4</td>
<td>4</td>
<td>248.5</td>
<td></td>
<td>0.13</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>i. Manage people*</td>
<td>4</td>
<td>3</td>
<td>302</td>
<td></td>
<td>0.36</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>j. Create jobs*</td>
<td>5</td>
<td>5</td>
<td>280</td>
<td></td>
<td>0.13</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>k. Follow a family tradition*</td>
<td>1</td>
<td>1</td>
<td>313.5</td>
<td></td>
<td>0.41</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>l. Gain high social status*</td>
<td>3</td>
<td>3</td>
<td>270</td>
<td></td>
<td>0.20</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>m. No job prospect*</td>
<td>3</td>
<td>1</td>
<td>159</td>
<td></td>
<td>0.009**</td>
<td>Gray et al. (2006)</td>
</tr>
<tr>
<td>n. Frustration of lack of satisfaction with current work/job*</td>
<td>3</td>
<td>2</td>
<td>247</td>
<td></td>
<td>0.27</td>
<td>Gray et al. (2006)</td>
</tr>
<tr>
<td>o. Badly needs money*</td>
<td>2</td>
<td>1</td>
<td>191.5</td>
<td></td>
<td>0.004**</td>
<td>Gray et al. (2006)</td>
</tr>
<tr>
<td>p. Great market opportunity*</td>
<td>4</td>
<td>4</td>
<td>274.5</td>
<td></td>
<td>0.320</td>
<td>Gray et al. (2006)</td>
</tr>
<tr>
<td>q. Previous work experience*</td>
<td>3</td>
<td>3</td>
<td>289</td>
<td></td>
<td>0.64</td>
<td>Gray et al. (2006)</td>
</tr>
<tr>
<td>r. Observed success of others*</td>
<td>4</td>
<td>3</td>
<td>296</td>
<td></td>
<td>0.58</td>
<td>Gray et al. (2006)</td>
</tr>
<tr>
<td>s. Being approached by a potential partner*</td>
<td>3</td>
<td>3</td>
<td>277</td>
<td></td>
<td>0.35</td>
<td>Gray et al. (2006)</td>
</tr>
<tr>
<td><strong>Q3. I would NOT start a business due to...</strong> (1 = Strongly Disagree, 5 = Strongly Agree)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Lack of ideas regarding what business to start</td>
<td>2.5</td>
<td>4</td>
<td>288</td>
<td></td>
<td>0.25</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>b. Lack of assistance available to assess business viability</td>
<td>3</td>
<td>4</td>
<td>275.5</td>
<td></td>
<td>0.80</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>c. Excessive risk</td>
<td>2</td>
<td>2</td>
<td>317.5</td>
<td></td>
<td>0.53</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>d. Lack of difficulty in getting initial capital for start-up</td>
<td>4</td>
<td>4</td>
<td>336.5</td>
<td></td>
<td>0.980</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>e. Lack of legal assistance or counseling</td>
<td>3</td>
<td>3</td>
<td>336.5</td>
<td></td>
<td>0.970</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>f. Lack of knowledge of the business world and the market</td>
<td>4</td>
<td>3</td>
<td>314.5</td>
<td></td>
<td>0.66</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>g. Lack of experience in management and finance</td>
<td>4</td>
<td>4</td>
<td>285</td>
<td></td>
<td>0.31</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>h. Current economic situation</td>
<td>3</td>
<td>2</td>
<td>347.5</td>
<td></td>
<td>0.95</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>i. Irregular income</td>
<td>2</td>
<td>2.5</td>
<td>324.5</td>
<td></td>
<td>0.80</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>j. Lack of support from people around me (family, friends, etc.)</td>
<td>1</td>
<td>1</td>
<td>345</td>
<td></td>
<td>0.91</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>k. Fear of failure</td>
<td>2</td>
<td>1</td>
<td>245</td>
<td></td>
<td>0.04</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>l. Doubts about personal abilities</td>
<td>2</td>
<td>1</td>
<td>364</td>
<td></td>
<td>0.14</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>m. Having to work too many hours</td>
<td>2</td>
<td>1</td>
<td>192.5</td>
<td>&lt;0.001***</td>
<td></td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>n. Problems with employees and colleagues</td>
<td>2</td>
<td>1</td>
<td>193</td>
<td></td>
<td>0.002**</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td><strong>Q5. Please rank your top choices for your future plans...</strong> (1 being your first choice, 9 being your last choice)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Start my own business or be self-</td>
<td>2</td>
<td>2</td>
<td>320</td>
<td></td>
<td>0.57</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>b. Work for a small business or start-up company</td>
<td>3</td>
<td>4</td>
<td>282.5</td>
<td></td>
<td>0.30</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>c. Work for a medium or large-size business</td>
<td>2.5</td>
<td>3</td>
<td>288</td>
<td></td>
<td>0.25</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>d. Work for the government</td>
<td>6</td>
<td>6</td>
<td>294</td>
<td></td>
<td>0.42</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>e. Serve in the military</td>
<td>9</td>
<td>9</td>
<td>337.5</td>
<td></td>
<td>1.0</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>f. Work for a non-profit organization</td>
<td>5</td>
<td>6</td>
<td>332</td>
<td></td>
<td>0.91</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>g. Attend graduate / professional school</td>
<td>3</td>
<td>3</td>
<td>304.5</td>
<td></td>
<td>0.40</td>
<td>Duval-Courtel et al. (2011)</td>
</tr>
<tr>
<td>h. Pursue unpaid work (household responsibilities, volunteering, child rearing, etc.)</td>
<td>8</td>
<td>6.5</td>
<td>229</td>
<td></td>
<td>0.07</td>
<td>USTM-TIES</td>
</tr>
<tr>
<td>Work in academia</td>
<td>6</td>
<td>7</td>
<td>324.5</td>
<td></td>
<td>0.99</td>
<td>USTM-TIES</td>
</tr>
<tr>
<td>j. Other (please specify)</td>
<td>8</td>
<td>4</td>
<td>0.5</td>
<td></td>
<td>0.26</td>
<td>USTM-TIES</td>
</tr>
</tbody>
</table>

* denotes pull factors; - denotes push factors

Table 2. Do motivations, deterrents, or future plans differ between men and women?
Is it possible to significantly change participant’s entrepreneurial attitudes, interest, and self-efficacy/entrepreneurial mind-set in a two-day workshop?

To evaluate what, if any, influence the two-day workshop had on entrepreneurial attitudes, interest, and self-efficacy/entrepreneurial mind-set, a 2-related sample Wilcoxon sign rank test was performed, matching responses for each participant from the pre- and post-survey. The null hypothesis for the statistical test was that the workshop had no effect and that the medians of the two compared groups were the same. Complete results of this test can be found in Table 3. To determine overall support for entrepreneurship, a single sample Wilcoxon sign rank test was also performed on the post-surveys for the same questions, testing whether the median for each item was statistically different than the neutral value of 3.

As indicated by Table 3, Questions 7 and 8 were concerned with entrepreneurial attitudes and interest and only two items reached significance. “I want to become an entrepreneur” showed a significant increase between the pre- \((mdn = 5.0)\) and post- \((mdn = 5.0)\) survey, \(p = 0.005\), although it should be noted these were both very favourable responses. Responses to the item “I have an idea for a business product or technology” also increased, with a pre- \((mdn = 3.0)\) to post- \((mdn = 4.0)\) significance level of \(p < 0.001\). The failure to reach significance on other items could be attributed to already high median scores on the pre-survey due to selection of the participants, since one of the criteria for participation was level of interest in entrepreneurship. On the post-survey, all items of the attitude/interest questions differed significantly from the hypothesized median of 3 (Median > 3) with significance \(p < 0.001\), suggesting that the participants felt overwhelmingly positive about entrepreneurship at the end of the workshop.

As expected, a strong increase in students’ self-efficacy was revealed, with 21 of the 27 items between Questions 9 and 11 showing a significant increase between pre- and post-workshop survey responses; see Table 3. For Question 9, participants’ confidence in their ability to “network – i.e., make contact with and exchange information with others,” \(p = .21\), to “get others to identify with and believe in
my vision and plans for a new business,” $p = .05$, to “clearly and concisely explain verbally / in writing my business idea in every day terms,” $p = .03$, and “inspire, encourage, and motivate employees,” $p = 0.11$, did not reach significance; in all cases the pre- and post- median were both equal to 4. The items that failed to reach significance in Question 11 were “constraints (e.g. financial or resource-wise) limit innovation,” $p = 0.298$, $mdn = 3$, and “the priority of an engineer is to make a profit for the company,” $p = 0.333$, $mdn = 4$, two of only three items in the question that do not explicitly refer to self-efficacy and which were not specifically addressed in the workshop.

A dramatic increase in self-efficacy of specified skills was also identified, with all items of Question 10 demonstrating significant increase between pre- and post- surveys; see Table 3. A single sample Wilcoxon sign rank test of self-efficacy items concluded that only three, “write a clear and complete business plan,” ($mdn = 3$, $p = 0.321$), “your ability to start a business now,” ($mdn = 2$, $p = 0.128$), and “constraints (e.g. financial or resource-wise) limit innovation,” ($mdn = 3$, $p = 0.723$) had a neutral median on the post- survey results, with all other items significant at $< 0.001$, indicating that participants still did not feel confident in these three areas.

The findings demonstrate that while entrepreneurial interest remained overwhelming positive from pre- to post-workshop, participant self-efficacy was significantly increased through the two-day workshop. These findings support the utility of short-programs for enhancing engineering entrepreneurial skillsets.
Table 3. Did pre-/post- surveys demonstrate changes in self-efficacy or attitudes/interest?

<table>
<thead>
<tr>
<th>Question</th>
<th>Pre-Median</th>
<th>Post-Median</th>
<th>Z-value</th>
<th>Pre-/Post- p-Value</th>
<th>Adapted From</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attitudes / Interest</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q7. In general, starting a business is...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. (1 = Worthless, 5 = Worthwhile)</td>
<td>5</td>
<td>5</td>
<td>-1.29</td>
<td>0.17</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>b. (1 = Disappointing, 5 = Rewarding)</td>
<td>5</td>
<td>5</td>
<td>-0.96</td>
<td>0.36</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>c. (1 = Negative, 5 = Positive)</td>
<td>5</td>
<td>5</td>
<td>-1.01</td>
<td>0.11</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>Q8. Please rate your level of agreement with the following...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. I have a general interest in the subject of entrepreneurship</td>
<td>5</td>
<td>5</td>
<td>-1.043</td>
<td>0.30</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>b. I want to become an entrepreneur</td>
<td>5</td>
<td>5</td>
<td>-2.840</td>
<td>0.005</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>c. I have an idea for a business product or technology</td>
<td>3</td>
<td>4</td>
<td>-3.60</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>d. I am interested in taking entrepreneurship classes</td>
<td>5</td>
<td>5</td>
<td>-0.63</td>
<td>0.53</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>e. Entrepreneurship education can broaden my career possibilities</td>
<td>5</td>
<td>5</td>
<td>-1.50</td>
<td>0.13</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>f. I would like to learn about entrepreneurship in my engineering courses</td>
<td>5</td>
<td>5</td>
<td>-9.10</td>
<td>0.37</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td><strong>Self-Efficacy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q9. How much confidence do you have in your ability to ...</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Brainstorm (come up with) a new idea for a product or service</td>
<td>4</td>
<td>4</td>
<td>-3.855</td>
<td>&lt;0.001</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>b. Identify the need for a new product or service</td>
<td>4</td>
<td>4</td>
<td>-3.978</td>
<td>&lt;0.001</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>c. Design a product or service that will satisfy customer needs and wants</td>
<td>4</td>
<td>4</td>
<td>-3.736</td>
<td>&lt;0.001</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>d. Get others to identify with and believe in my vision and plans for a new business</td>
<td>4</td>
<td>4</td>
<td>-1.980</td>
<td>0.05</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>e. Network - i.e. make contact with and exchange information with others</td>
<td>4</td>
<td>4</td>
<td>-1.256</td>
<td>0.21</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>f. Clearly and concisely explain verbally / in writing my business idea in everyday terms</td>
<td>4</td>
<td>4</td>
<td>-2.225</td>
<td>0.03</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>g. Inspire, encourage, and motivate employees</td>
<td>4</td>
<td>4</td>
<td>-1.619</td>
<td>0.11</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>h. Pick the right marketing approach for the introduction of a new service</td>
<td>3</td>
<td>4</td>
<td>-3.360</td>
<td>0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>i. Recognize when an idea is good enough to support a major business venture</td>
<td>4</td>
<td>4</td>
<td>-2.946</td>
<td>0.003</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>j. Estimate customer demand for a new product or service</td>
<td>3</td>
<td>3</td>
<td>-3.141</td>
<td>0.002</td>
<td>McGee et al. (2006)</td>
</tr>
<tr>
<td>k. Convert a useful scientific advance into a practical application</td>
<td>3</td>
<td>4</td>
<td>-3.847</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>l. Write a clear and complete business plan</td>
<td>3</td>
<td>3</td>
<td>-2.636</td>
<td>0.008</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>m. Grasp the concept and limits of a technology well enough to see the best ways to use it</td>
<td>3</td>
<td>4</td>
<td>-4.237</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>n. Lead a technical team developing a new product to a successful result</td>
<td>4</td>
<td>4</td>
<td>-3.878</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>o. Translate user needs into requirements for a design so well that the users will like the outcome</td>
<td>3</td>
<td>4</td>
<td>-4.182</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>Q10. Please rate your level of knowledge of the following areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Prototyping</td>
<td>2</td>
<td>4</td>
<td>-5.019</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>b. Market research</td>
<td>3</td>
<td>3</td>
<td>-4.874</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>c. Competitive analysis</td>
<td>3</td>
<td>3</td>
<td>-3.926</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>d. Engineering creativity</td>
<td>3</td>
<td>4</td>
<td>-5.131</td>
<td>&lt;0.001</td>
<td>USTM-TIES</td>
</tr>
<tr>
<td>e. Engineering innovation</td>
<td>3</td>
<td>4</td>
<td>-5.356</td>
<td>&lt;0.001</td>
<td>USTM-TIES</td>
</tr>
<tr>
<td>f. Engineering entrepreneurship</td>
<td>3</td>
<td>4</td>
<td>-4.751</td>
<td>&lt;0.001</td>
<td>USTM-TIES</td>
</tr>
<tr>
<td>g. Your overall entrepreneurial ability</td>
<td>3</td>
<td>4</td>
<td>-4.699</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
<tr>
<td>h. Your ability to start a business now</td>
<td>2</td>
<td>3</td>
<td>-4.453</td>
<td>&lt;0.001</td>
<td>Duval-Couetil et al. (2011)</td>
</tr>
</tbody>
</table>

Table 3. Did pre-/post- surveys demonstrate changes in self-efficacy or attitudes/interest?
Discussion

From this study we identified several key findings emphasizing contextually relevant factors and how they can support engineering entrepreneurship and efforts for economic stability in Morocco. These items are discussed next in relation to the delineated research questions and existing literature.

**Moroccan undergraduates are motivated to pursue entrepreneurship to fulfill personal goals and aid in the development of their country, but face difficulties acquiring capital and finding assistance.**

Our first research question addressed the factors that motivate and deter engineering students from pursuing entrepreneurship. Our findings suggest that the participating Moroccan engineers were overwhelmingly being pulled into entrepreneurship by opportunity, supporting previous qualitative findings by Gray, et al. (2006). None of the three push factors analysed were ranked highly as reasons participants would pursue entrepreneurship. This is consistent with research suggesting that classification as a traditional culture by the World Values Survey, such as Morocco is, anticipates an increase in pull entrepreneurship (Hechavarria & Reynolds, 2009). It is not surprising that “gain high social status” and
the related item, “observed success of others,” were among the statistically neutral items: Muslim cultures tend to be more interdependent, favouring collective success over individual triumph (Farid, 2007). The strongest pull factors, as indicated by median, were to satisfy a need in a market, solve a social problem, create something of my own, and create jobs. The pull trend is clear, and it is notable that the key factors tend to be collectivist and are reflected in participants’ open-responses, supporting Farid’s (2007) assertion that entrepreneurs in North Africa may have fundamentally different motives for entering entrepreneurship than those in the United States.

Analysis of deterrents to starting a business revealed that “excessive risk” was insignificant, suggesting that it would not be a preventative factor in starting a business and consistent with “fear of failure” being rated low. This is an interesting finding considering it refutes Farid’s (2007) assertion that North African cultures are risk averse. It is possible that this dichotomy is attributable to the privileged education of the workshop participants and thus generalization beyond elite engineering students in Morocco should be made with caution. The only factor identified as deterring participants from starting their own business was a lack of or difficulty in getting initial capital for start-up, supporting the claim that procurement of capital can be difficult in North African nations (Farid, 2007).

Overall, our results show that Moroccan engineering students are pulled into entrepreneurship, although it is important to note that findings suggest their motivations are fundamentally different than those commonly experienced in the United States and tend to reflect the more collectivist culture. Future work should explore whether or not these findings are consistent across all educational and socioeconomic levels and should seek to investigate these motivational questions beyond students and to practicing technological entrepreneurs.
Men and women exhibit similar career plans, entrepreneurial motivations, interest, attitudes, and self-efficacy, with men demonstrating higher push influences

Our second research question asked whether gender affects entrepreneurial motivation, interest, attitudes, and self-efficacy. Interestingly, men and women differed on two of the three push factors, with men rating them higher. Results imply that contrary to Gray, Foster, and Howard’s (2006) findings, Moroccan men may be slightly more likely to be pushed into entrepreneurship than women since men rated the push factors as stronger motivators. This difference may be due to the fact that our participant pool consisted of approximately 50% women, while the previous study (Gray, et al., 2006) had fewer than 10% women. In addition, it is found that women in North African countries are largely pulled into entrepreneurship, although women with university diplomas are actually less likely than uneducated women to participate in early-stage entrepreneurial activities in Morocco (Hattab, 2012a). The current finding should be interpreted with caution since it is also possible that these results are due to internalization of normative gender roles; among the group of elite students that were examined, it may be more socially acceptable for men to serve as breadwinners, to provide for women and ensure they do not have to work. The participants in this study hold high status in society and as such may be expected to follow traditional gender roles. This theory is consistent with the third item displaying motivational difference, “make more money,” suggesting that men place a higher value on the earning potentials of entrepreneurship.

In conjunction with women exhibiting lower push factors, women are less likely to view having to work too many hours and problems with employees and colleagues as factors that would prevent them from beginning their own business. This lends additional support to the argument that female Moroccan engineers may be pulled more into entrepreneurship than their male counterparts; female engineers are less likely than men to be influenced by push factors or perceive obstacles. There was no difference between the rankings of future careers that men and women reported wanting to pursue. Women expressed more interest in taking entrepreneurship classes, but did not reveal any difference from men in
self-efficacy, attitude, or other interest items. These findings add to the mixed results on female entrepreneurship, refuting studies that have variously shown women to exhibit less entrepreneurial interest, less positive attitudes, and lower entrepreneurial and engineering self-efficacy (Chen, et al., 1998; Harbi, et al., 2009; W. A. Lucas, et al., 2009; Wilson, et al., 2007). Additional research is warranted in the area of gender and entrepreneurial self-efficacy, particularly in North Africa, so that the full potential and education of women might be utilized into technological venture creation.

**Short-term programs can encourage entrepreneurial interest and self-efficacy**

The final research objective was to investigate whether it is possible to significantly change participants’ entrepreneurial attitudes, interest, and self-efficacy/entrepreneurial mind-set in a two-day workshop. As evidenced through the results, the workshop clearly had a positive effect on participants’ entrepreneurial interest and self-efficacy. It is important to recognize that the item with the most significant change was “I have an idea for a business product or technology,” suggesting that the workshops accomplished the goal of identifying new technologies with commercial values and that creativity and innovation lessons were particularly well received. Although only two items of attitude/interest measures showed change, this result is likely a consequence of the selection of the participant pool. In order to be considered for the workshop, applicants had to demonstrate motivation and interest in pursuing entrepreneurship. The failure to achieve significant change for other items merely suggests that AMIDEAST successfully recruited its target population, with participants reporting high medians for interest on the initial survey.

Consistent with the literature, a strong increase in students’ self-efficacy was observed. No significant changes were detected for the networking and employee motivation items, suggesting that future workshops might allow additional time for interactions between participants and for individuals to attempt leadership roles. While most of the items were rated above neutral on the pre- and post- surveys,
the significant differences between the two show that the workshop nevertheless increased participants’
self-efficacy even further. Taken collectively, these findings offer substantial evidence that engineering
entrepreneurship self-efficacy can be significantly improved through short-form educational methods.

It was found that the items “constraints (e.g. financial or resource-wise) limit innovation,” and
“the priority of an engineer is to make a profit for the company,” did not show significant change due to
the workshop. These areas were not specifically addressed during the current workshops, but can be
identified as areas of focus for future iterations. Although significant increases in efficacy of specific
skills were found, particularly in prototyping, the item “write a clear and complete business plan”
remained statistically neutral. While the current program offers a successful model of teaching
innovation, creativity, and entrepreneurial mind-set, it does not teach specific business skills. Future
work should investigate additional combinations of topics as well as various teaching and learning
techniques in order to optimize the benefits and accommodate differing objectives.

Limitations & future work

While this work has revealed important findings about the effectiveness of short-form
entrepreneurship education and the entrepreneurial motivations of Moroccan engineering students, our
results have some limitations that identify need for future research.

The participants selected for this study came from the top two engineering and science schools in
Morocco and were chosen based on their interest in entrepreneurial activity. This population was selected
because we sought to identify the perceived challenges that exist to those that have the most potential to
pursuit entrepreneurial activities. While ideal for the objective of actively encouraging new technology
venture creation in Morocco, the results may not be generalizable to the engineering and science
population at large. Therefore, future studies should focus on replicating this study with other, less elite,
engineering groups to ensure generalizability throughout Moroccan society. In addition, only fifty-five
students participated in this study. While this sample is likely representative of the approximately 9,000 individuals currently in undergraduate Moroccan engineering education (Statistiques Universitaires 2010-2011, 2011), future studies should be conducted on a larger sample. Finally, the research findings presented here report only the immediate impact of the workshop activities on the participants and thus future studies should explore the long-term impact of the workshop to see if gains were retained or were simply a by-product of enthusiasm from the event itself.

Future work may also wish to consider a comparison of the current workshop model to longer, full-semester courses offered at universities. Literature suggests that self-efficacy is key to entrepreneurial learning and is positively correlated with intent to start a business (Borchers & Park, 2010; Chen, et al., 1998; W. Lucas & Cooper, 2004; Zhao, et al., 2005) and we have demonstrated that it can be significantly improved through a short-form workshop with a combination of lectures and hands-on activities. The practice of enactive mastery over traditional theory and knowledge in a non-graded atmosphere may prove to be highly beneficial.

Conclusions

Encouraging entrepreneurship, particularly in high growth areas such as technology, in North Africa is of paramount importance to stabilizing the economy in the region. The objectives of this study were to investigate what motivates Moroccan engineers to pursue or avoid entrepreneurship, to see if gender affects entrepreneurial motivators, deterrents, interest and self-efficacy, and to test whether a short-form workshop can significantly increase entrepreneurial interest and self-efficacy among young engineers. These goals were accomplished by surveying 55 undergraduate participants before and after their involvement in a two-day workshop focused on teaching innovation, creativity, and instilling an engineering entrepreneurial mind-set.
Findings suggest that Moroccan engineers are overwhelmingly pulled into entrepreneurship. Only concern about procuring capital was considered a true obstacle to business creation. Relating to gender, our findings contradict previous literature, suggesting that women are less likely than men to be pushed into entrepreneurship, perhaps due to perceived benefits that women may not receive in traditional engineering careers. Although women exhibited lower ratings of push factors, men and women exhibited no significant difference in career rankings. While these findings are clear, they could be due to the specificity of the well-educated group of engineers under consideration and the subject warrants further investigation.

This study contributes to the limited research on Moroccan entrepreneurship, offering valuable insights into the entrepreneurial motivators and obstacles faced by young engineers, suggesting that, contrary to popular belief, women by and large exhibit the same entrepreneurial interest and self-efficacy as men, and are more likely to be pulled than pushed into venture creation. Finally, our results demonstrated that short-term workshops can significantly increase engineering entrepreneurship interest and self-efficacy, offering a valuable alternative to undergraduate engineering programs interested in offering entrepreneurship education without the need to redesign curricula or force additional coursework upon students. Future work should explore the effect of this type of program for students with less initial interest in engineering entrepreneurship and also explore the longitudinal impact of these short-term programs.
References


2012 USTM Workshop Survey Results. from http://www.engr.psu.edu/ustm/morocco_files/Pre-Survey-Results.pdf; http://www.engr.psu.edu/ustm/morocco_files/Post-Survey-Results.pdf


Appendix 1. Surveys used

US-MOROCCO WORKSHOP FOR TECHNOLOGY INNOVATION AND ENTREPRENEURSHIP STIMULATION

DEMOGRAPHICS

Please state your gender:

☐ MALE ☐ FEMALE

Please choose the range that identifies your age:


Occupation (please choose one):

☐ STUDENT ☐ PROFESSIONAL ☐ PROFESSOR

Please state your major or area of professional expertise (e.g. Mechanical Engineer):


Have either or your parents started or been part of a new business venture?

☐ ONE PARENT ☐ BOTH PARENTS ☐ NEITHER PARENT ☐ UNSURE

If so, please describe the business below.


Has anyone in your family (not your parents) started or been part of a new business opportunity?

☐ YES ☐ NO

How many entrepreneurship-focused courses have you taken?

☐ 0 ☐ 1 ☐ 2 ☐ 3+
The following questionnaire was developed in order to understand your interest and knowledge of entrepreneurship and innovation. For the following questions, please either circle the numeric response (1-5) for each of the questions below or provide a detailed written response in ENGLISH.

Please circle the numeric response (1-5) for each of the following questions

<table>
<thead>
<tr>
<th>1. Why you would start a business due to/in order to...</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus on a technology that interests me</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Satisfy a need in a market</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Solve a social problem</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Create something of my own</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Have more flexibility and independence</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Have more free time</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Make more money</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Be at the head of an organization</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Manage people</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Create jobs</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Follow a family tradition</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Gain high social status</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>No job prospect</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Frustration or lack of satisfaction with current work/job</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Badly needs money</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Great market opportunity</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Previous work experience</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Observed success of others</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Being approached by a potential partner</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

2. If there are any reasons not listed above for why YOU would start a business, please list them here.
Please circle the numeric response (1-5) for each of the following questions

3. I would NOT start a business due to...

<table>
<thead>
<tr>
<th>Reason</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of ideas regarding what business to start</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Lack of assistance available to assess business viability</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Excessive risk</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Lack of/ difficulty in getting initial capital for start-up</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Lack of legal assistance or counseling</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Lack of knowledge of the business world and the market</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Lack of experience in management and finance</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Current economic situation</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Irregular income</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Lack of support from people around me (family, friends, etc.)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Fear of failure</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Doubts about personal abilities</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Having to work too many hours</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Problems with employees and colleagues</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

4. If there are any reasons not listed above for why YOU would NOT start a business, please list them here.

5. Please rank your top choices for your future plans (1 being your first choice, 9 being your last choice):

   ________ Start my own business or be self-employed
   ________ Work for a small business or start-up company
   ________ Work for a medium or large-size business
   ________ Work for the government
   ________ Serve in the military
   ________ Work for a non-profit organization
   ________ Attend graduate/professional school
   ________ Pursue unpaid work (household responsibilities, volunteering, child rearing, etc.)
   ________ Work in academia
   ________ Other (please specify): __________________________

6. Please briefly explain what motivated YOU to pick your top choices:

   ____________________________________________________________
Please circle the numeric response (1-5) for each of the following questions

7. In general, starting a business is...

<table>
<thead>
<tr>
<th>Worthless</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Worthwhile</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disappointing</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>Rewarding</td>
<td>5</td>
</tr>
<tr>
<td>Negative</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>Positive</td>
<td>5</td>
</tr>
</tbody>
</table>

8. Please rate your level of agreement with the following:

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Strongly Agree</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have a general interest in the subject of entrepreneurship</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>I want to become an entrepreneur</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>I have an idea for a business product or technology</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>I am interested in taking entrepreneurship classes</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Entrepreneurship education can broaden my career possibilities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>I would like to learn about entrepreneurship in my engineering courses</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Please circle the numeric response (1-5) for each of the following questions

9. How much confidence do you have in your ability to...

<table>
<thead>
<tr>
<th>Activity</th>
<th>Very Little</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brainstorm (come up with) a new idea for a product or service</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Identify the need for a new product or service</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Design a product or service that will satisfy customer needs and wants</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Get others to identify with and believe in my vision and plans for a new business</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Network - i.e., make contact with and exchange information with others</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Clearly and concisely explain verbally/in writing my business idea in everyday terms</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Inspire, encourage, and motivate employees</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Pick the right marketing approach for the introduction of a new service</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Recognize when an idea is good enough to support a major business venture</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Estimate customer demand for a new product or service</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Convert a useful scientific advance into a practical application</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Write a clear and complete business plan</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Grasp the concept and limits of a technology well enough to see the best ways to use it</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Lead a technical team developing a new product to a successful result</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Translate user needs into requirements for a design so well that users will like the outcome</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Please circle the numeric response (1-5) for each of the following questions

10. Please rate your level of knowledge of the following areas:

<table>
<thead>
<tr>
<th>Area</th>
<th>Poor</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototyping</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Market research</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Competitive analysis</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Engineering creativity</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Engineering innovation</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Engineering entrepreneurship</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Your overall entrepreneurial ability</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Your ability to start a business now</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Only students need to answer Question 11

<table>
<thead>
<tr>
<th>11. Please rate your level of agreement with the following statements (STUDENTS ONLY)</th>
<th>Strongly Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I understand what it takes to start a business venture</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Constraints (e.g. financial or resource-wise) limit innovation</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>The priority of an engineer is to make a profit for the company</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>A failure, after giving it my best shot, is as respectable as a successful endeavor</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I am capable of giving constructive feedback on an engineering design</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I am good at integrating engineering concepts into my work</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I can create something valuable out of minimal resources</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I am good at persuasively voicing my opinions</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I am good at clearly articulating my ideas with concise and precise words</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I can convert my creativity to solve real problems</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I am good at making decisions when information is lacking or ambiguous</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>Given a project goal, I can identify the right kind of people I need on my team</td>
<td>1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>
12. Please rate your level of agreement with the following with respect to the USTM-TIES program:

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programs/lectures met objectives</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Materials used for program were appropriate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content increased understanding of product development process</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge/skills gained will be applied in future case studies or internships</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program provided network opportunities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Program allowed enough time to interact with private sector/academia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hands-on activities enhanced my understanding of the topics and practices described in the lectures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13. Do you remember any specific “event” or input during the program that particularly inspired you to consider becoming an entrepreneur? If so, please describe it.

14. To what extent did such events make you seriously consider embarking on an entrepreneurial career?

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>To a large extent</th>
</tr>
</thead>
</table>
15. Which part of the program was most useful to you and why?

16. What aspect of the hands-on activities did you find most useful to you and why?

17. How many new contacts in academia have you made during this workshop? 0 1 2 3 4 5 6+

18. How many new professionals/contacts in industry have you made during this workshop? 0 1 2 3 4 5 6+
Chapter 4

The scissor effect: Challenges and response strategies for encouraging Moroccan women to pursue engineering and science careers

Samantha Adams and Scarlett Miller

Submitted for consideration to the Journal of Engineering Education, July 2013

Abstract

Background – While women represent a higher proportion of engineering and science students in Morocco compared to other countries there is a large drop-off after college graduation, resulting in losses of human capital, economic growth, and societal wellbeing.

Purpose/Hypothesis – The objective of this research was to identify perceived challenges and what factors contribute to the radical reduction of female engineers in science, engineering, and technology (SET) fields after college graduation. Response strategies are also detailed, addressing perceptions associated with pursuing technological entrepreneurship as well as development of mentoring programs.

Design/Method – A series of focus groups and semi-structured interviews were conducted with 30 women from two Moroccan science and engineering universities to understand perceived career challenges, perceptions of entrepreneurship, mentoring relationships, and identify strategies to overcome barriers.

Results – Results indicate that there are numerous factors that contribute to women’s underrepresentation in the SET workforce including perceived stereotyping, discrimination, career/family balance concerns, and internalized gender norms. While entrepreneurship may help to overcome some of these challenges, the main barrier identified was work/family balance. A distinct need for mentoring was identified among participants, which may help overcome these challenges.
**Conclusions** – Although entrepreneurship was a perceived alternative for women seeking SET-related careers, lack of capital was cited as a primary problem; accordingly, educational opportunities in venture creation and capital procurement are recommended. These findings contribute to the knowledge of Moroccan women in SET domains and the factors that contribute to their decreased representation post-graduation; they are used to develop response strategies that will encourage women’s participation in the SET workforce.

**Introduction**

In Morocco, women represent 45% of science and 26% of engineering graduates (UNESCO, 2012), and a reported 50.8% of new engineering students (Statistiques Universitaires 2010-2011, 2011); this represents a drastic difference from the United States where women account for a smaller proportion of science and engineering students (41% and 19%, respectively) (UNESCO, 2012). However, this advantage quickly deteriorates after college graduation when the percent of females in SET drops radically in the Middle East and North Africa (MENA) region (Dewedar, 2012; Qayyum, 2012). While male unemployment rates tend to decrease with educational level in North Africa, women’s actually increase (Chamlou, Iqbal, & Reinikka, 2009). In fact, research has shown that in times of high unemployment this effect is exasperated by decision makers’ fear that increasing the number of women in the workforce will lead to a decrease in men’s employment rates (Chamlou, et al., 2009). This largely unexplored phenomenon is known as the “scissor effect”, which describes the loss of human capital associated with women that occurs between the time they enter higher education and the time they enter the workforce (Bahmani, et al., 2012). Understanding the factors that influence this scissor effect is crucial because educated North African women represent an unexploited source of human capital, leading to loss of jobs, economic growth, and wellbeing for families (Cheikh, 2010).
While women in North Africa have recently been provided with more opportunities to enter into science, engineering and technology (SET) education (Dewedar, 2012), there are obstacles that still need to be examined that prevent or deter women from pursuing careers in these fields. For example, at the turn of the millennium the migration of North African male workers left a void in the job market which allowed women to move into fields where access was previously restricted, including engineering (Fernea, 2000). However, only one third of women in Morocco work full-time across all industries, with even fewer women present in the upper echelons of industry (Bahmani, et al., 2012; Fernea, 2000; Harbi, et al., 2009). Hassan (2000) noted that this might be due to the fact that career opportunities for women in Muslim countries, particularly among scientific organizations, tend to be more limited than for men. In addition to limited job opportunities, other factors may contribute to the deterioration of female representation in the SET workforce, including work / family balance and perceived bias (Hill, Corbett, & Rose, 2010). However, few research studies have been conducted on the influence of these dynamics in Morocco and therefore it is unknown how such factors affect the decision to pursue a SET career. Understanding these obstacles and providing strategies to overcome them is key for encouraging and supporting women to persevere and advance in (SET) careers.

In order to address the problem of perseverance and the loss of women’s talents from the workforce, studies have identified ways to support women in entering SET careers through the building of entrepreneurial skillsets and with mentoring programs. The development of entrepreneurial skillsets is often stressed because it offers an alternate SET career path with a better balance between work and personal responsibilities, as well as additional freedom and control over professional ambitions (Coughlin, 2002; McGowan, Redecker, Cooper, & Greenan, 2012). This is important because such barriers create concern for women entering traditional SET careers (Muller & Barsion, 2003). Career mentoring has also been identified as a crucial strategy for supporting women in SET (Chovwen, 2007) because it has been shown to encourage women to persevere with science and engineering (Packard, 2004), to broaden women’s horizons to new departments and industry opportunities (Muller, 1997), and can
provide a means of support and encouragement that can positively influence determination (Chovwen, 2007). While both of these avenues offer potential strategies to aid Moroccan women in pursuing careers in SET, the perceptions of the benefits associated with each have not been studied in Morocco, leaving it unclear how these particular approaches can be used to encourage women to employ their SET education and skills.

Therefore, this study was developed to understand the factors that influence the scissor effect in engineering and science in Morocco and to provide an understanding of response strategies that can be used to mitigate this effect through mentorship and entrepreneurial activities. In order to accomplish this a series of focus groups and interviews with Moroccan engineering and science students were conducted. The findings are used to provide recommendations for strategies to increase participation of well-educated Moroccan women in the science, engineering, and technology workforce. Although studied in Morocco, we hope that these strategies can be generalized to other North African countries in order to fully capitalize on the human capital and the resulting economic improvement.

Related Work

Women in science and engineering in Morocco

Women represent 45% of science and 26% of engineering graduates in Morocco (UNESCO, 2012) and 50.8% of new engineering students are women according to the Moroccan Ministry of Higher Education (Statistiques Universitaires 2010-2011, 2011). While women are well represented in Moroccan university-SET education, the participation of female engineers and scientists in industry regresses post-graduation (Qayyum, 2012), a phenomenon referred to as the “scissor effect” where human capital is lost before translation into the workplace (Bahmani, et al., 2012). While the UN Division for the
Advancement of Women (Sept 2010) notes that the transition from education to industry is a large hurdle across countries, the causes of this scissor effect in SET in Morocco are largely unknown.

Although the role of women in engineering and science has not received much attention in Morocco, global discussion of women’s underrepresentation in science and engineering generally revolves around three main issues: women’s scientific ability, interest and personal choices, and work environment (Hill, et al., 2010). In particular, Henes et al. (1995) found that women are more likely to be discouraged about their engineering education, are less confident about their future in SET, and are often less comfortable asking questions; this is consistent with findings that women are less likely to persist in their SET career aspirations (Mau, 2003). Hassan (2009) also points out that Muslim countries such as Morocco, may have more limited career opportunities for female SET graduates which may greatly impact the scissor effect. Internationally, family and culture issues have also been cited as reason for women’s attrition from science domains; a recent study reported that, “there was, and often still is, a de facto end to participation in [science, technology, engineering, and mathematics] research and practice after women finish their university studies or get married” (Sengers, et al., 2008, p. 863). This may be attributed to a lack of time due to household responsibilities that can be seen as significant obstacles to fulfilling career goals (Bahmani, et al., 2012; Bal et al., 2004; Hijab, 1988). Finally, researchers often identify the work environment as a barrier to SET entrance, where issues such as lack of inclusion, isolation, and lack of role models may lead women to exit the SET profession (Henes, et al., 1995; Marra, et al., 2009).

Though work has been conducted in an effort to address the underrepresentation of women in SET (Hill et al., 2010; Mau, 2003), research has not examined these questions in Morocco. While the discrepancy between women receiving engineering degrees and those employing their skills in industry suggests a loss of valuable human capital (Cheikh, 2010), the rationale behind this deficit in Morocco remain unclear. Therefore, this work seeks to understand the perceived challenges in the transition from education to SET career that Moroccan women face.
Women in entrepreneurship in Morocco

One potential way to overcome this scissor effect in Morocco is through entrepreneurial activities since entrepreneurship has been identified as a possible outlet for women’s talents in countries where there are few opportunities for traditional industry employment (Cetindamar, Gupta, Karadeniz, & Egrican, 2012). In fact, research has shown that women often enter entrepreneurship with the belief it can offer increased balance between work and personal responsibilities (McGowan, et al., 2012). However, while entrepreneurship can remove some of the perceived barriers to entering SET careers (e.g. isolation and lack of inclusion in the work environment), entrepreneurship carries a masculine association, (Gupta, et al., 2009; Harbi, et al., 2009; Zeffane, 2013), which may prove to be a distancing or marginalizing factor for women seeking to enter such fields (Chesler & Chesler, 2002). Therefore, exploring motivation and barriers to entrepreneurial activities in SET in Morocco and the difference between male and females attitude towards entrepreneurship is of vital importance.

Although not studied in Morocco, research on entrepreneurship has found that women’s perceptions of their entrepreneurship ability is lower than that of men (Duval-Couetil, et al., 2010) and that they often exhibit less self-confidence about starting a business (Bahmani, et al., 2012). This may be attributed to the fact that women tend to lack social networks, which can greatly hinder their ability to procure start-up capital (Bahmani, et al., 2012). However, when examining the question of entrepreneurial intention and feasibility in Tunisia, another North African country, El Harbi et al. (2009) found no significant difference in men and women’s reports of resource or information availability, but did identify a statistical difference between their ratings of feasibility and their attitude toward beginning a business. He notes that it is the young and educated people themselves who have negative attitudes of female entrepreneurship and who do not approve of women’s venture creation. Manolova et al. (2012) also argued that it is not only more socially acceptable for males to be entrepreneurs, but males are more able to focus on financial success without praise or recognition. Thus, regardless of education, perceived social norms may confine women to a more gender-traditional path (Harbi, et al., 2009). Although
cultural traditions may deter women from pursuing entrepreneurship, recent research suggests that there are no innate differences that would prevent women from excelling in the field (Zeffane, 2013).

Although entrepreneurial activities can provide an alternate means for women to enter SET careers, women’s motivation for pursuing entrepreneurship is more complex than men’s, involving internal as well as external motivators (Manolova, Brush, Edelman, & Shaver, 2012). However, few studies have explored the motivation and perceived challenges for women’s entrepreneurial activities in Morocco. Therefore, this study responds to this research gap by exploring entrepreneurship as a feasible outlet for the talents of women in SET in Morocco.

**Mentoring systems and practices in Morocco**

Since lack of confidence is identified as a barrier for women entering SET careers (Hawks & Spade, 1998), either traditional or entrepreneurial, the benefits of having a mentor to encourage young women could prove vital. In fact, mentoring has been identified as a crucial strategy for persistence in male dominated occupations (Chovwen, 2007), and the importance of having female role models and mentors in male-dominated fields is consistently stressed in the literature (Sengers, et al., 2008; UNESCO, September 2010). Chovwen (2007) cites benefits of mentoring to include support and encouragement, and positively influencing attitudes and improved determination, which have been shown to encourage women to persevere with science and engineering and to broaden their horizons to new departments and industry opportunities (Muller, 1997; Muller & Barsion, 2003).

While mentoring may prove helpful in encouraging and supporting women in Morocco who enter SET careers, the type of mentoring relationship can have a large impact on the type of motivation encountered. For example, some mentorship programs stress providing only minimal guidance to the mentee, allowing the individual to encounter challenges and prevail on their own (Chesler & Chesler, 2002), while others focus on support and friendship, forming interpersonal as well as work relationships...
Findings also point to developing mentoring relationships with a non-supervisory mentor (either from a different department or from industry), as it alleviates tension that might be created by the power discrepancy between a student and instructor (Putsche, et al., 2008). Finally, mentoring “teams” and peer mentoring have been identified as more inclusive models that may be more welcoming to women (Chesler & Chesler, 2002). Such alternative mentoring models offer the chance for a more communal setting, where the mentee can receive support and get multiple perspectives in a less formal setting that is more consistent with women’s socialization (Chesler & Chesler, 2002). Peer mentoring may also reduce the undesirable competitive aspects of SET education and employment (Chesler & Chesler, 2002).

While the benefits of mentoring have been well studied, the existence of mentoring relationships or the need for such programs for Morocco women in SET is unclear. Therefore, this research seeks to understand Moroccan women’s perceptions of mentoring, to determine if there is a need, and, if so, to understand how to establish such relationships in Morocco.

**Research questions and objectives**

The review of existing literature has indicated a discrepancy between the representation of university women in engineering and science and the number of females in the engineering workforce in Morocco. While some have speculated that the opportunities for employment are more limited for Moroccan women (Hassan, 2000), the exact reasons for the scissor effect in Morocco are unclear. Additionally, response strategies for reducing this effect through entrepreneurship and mentoring programs remains largely unexplored in Morocco. Therefore, the current study was developed to investigate the following research questions:

1. What factors contribute to the “scissor effect” of Moroccan female engineers?
2. What factors contribute to Moroccan women’s pursuit of technological entrepreneurial activities and what perceived obstacles exist?

3. How can mentoring be used to encourage women to enter the SET workforce in Morocco?

In order to answer these questions, two studies were conducted with Moroccan undergraduate and graduate women in SET including focus groups and a series of interviews. This two-part method was selected because while focus groups allow for a broad range of opinions and insights that can reveal trends, similarities, and differences, fewer topics are covered and there is the danger of group think (Fontana & Frey, 1994). On the other hand, individual interviews allow for more in-depth discussion from a unique perspective that is not subject to silencing by the group (Lazar, Feng, & Hochheiser, 2010). Therefore, in this study we used both focus group and individual interviews in order to allow for both diversity of opinion and detailed insights into a wide array of questions. This strategy has also been employed by researchers investigating barriers faced by Nigerian women (Chovwen, 2007). The methodology of the two studies is described below, followed by a joint report of results and discussion.

Methodology

Participants

Participants were recruited from two Technology Innovation and Entrepreneurship Stimulation workshops held in two Moroccan cities in the spring of 2013. Workshop participants were recruited from the two most elite engineering and science schools in Morocco and were screened by AMIDEAST Morocco for English proficiency, degree of entrepreneurial motivation, and academic ranking. Participants were recruited from this workshop by inviting the women to a “special, closed women in engineering and science focus group session.” In all, 30 female Moroccan engineering and science
undergraduate and graduate students participated in the focus group study. For the second study, participants were recruited for individual interviews through email requests sent to focus group participants. A total of seven female students participated in these interviews.

It is important to note that there are only approximately 4,000 female engineering students in Moroccan universities (Statistiques Universitaires 2010-2011, 2011) in contrast to roughly 88,700 females enrolled in the United States (Yoder, 2012). Therefore, conducting an in-depth study with 30 participants can provide insights to the population at large.

Procedure

Prior to the start of the focus group, the participants completed a collage activity where they were provided with engineering magazines and asked to develop a collage that represented “the current state of women in engineering and science in Morocco.” After 30 minutes, the women presented their collages to their peers; see Figure 1 for an example. At the end of the presentations, each woman was asked to write down the top challenges they felt faced women in engineering and science in Morocco, which was used to generate discussion during the study.

![Figure 4-1: Focus Group Collaging Activity](image)

At the start of the study, the women were informed of the purpose of the research and any questions were answered. Once verbal consent was attained, the women were broken into two focus
groups of 5-8 members. Next, the focus groups were lead by the researchers, including questions on educational motivation, employment plans, and mentors / role models; see Figure 2 for question list. The focus group lasted approximately 1.5 hours and was audio-recorded and later transcribed. This procedure was replicated in both Moroccan cities.

Focus Group, "Motivation, Future Career Plans, and Obstacles for women in STEM in Morocco"

Educational Motivation
1. Can you tell me about why and how you decided to pursue a career in engineering/science?
2. What kind of support or discouragement did you get from your peers and family for making the choice to pursue a degree in engineering/science?
3. Are there any obstacles that females experience in engineering/ sciences in Morocco that males do not? What are they?
4. Have you experienced any obstacles as a female in engineering and sciences? If so, what were/ are they?

Employment Plans
5. What plans do you have to enter the engineering/science workforce after graduation? Why or why not? If yes, what type of company will you be applying to?
6. What factors affect your decision to enter or not enter the workforce post-graduation (e.g. family pressures, etc.)?
7. Do you perceive any challenges as a female trying to enter the workforce/ find a job? What are they?

Mentoring & Role Models
8. Do you think having a role model/ mentor in your field is important? Why or why not?
9. What is the prevalence of female role models in engineering and science in Morocco?
10. Do you think that female role models are important in engineering/science? Why or why not?
11. Under what situations, if any, do you think a female role model would better support your career choice over a male or vice-versa?
12. Is there any other information you would like to talk about with regard to the status of women in science and engineering in Morocco?

Figure 4-2. Focus Group Topics List
Participants were recruited for individual interviews by emailing the focus group participants. Next, interested participants were emailed a copy of the interview questions and IRB documents and consent for participation was attained. A 21 question semi-structured interview was conducted with consenting participants using the Skype video calling system. The interview included questions on career intentions, consideration and views of entrepreneurship, and mentoring; see Figure 3 for question list. Each interview lasted approximately one hour and was audio-recorded for future analysis.
Interview Questions

Background Information
1. Can you please tell me about your major and how you came to select your major?
2. Did you have any mentors early in your life or education that helped you make your decisions on which career path to pursue?
   a. If so, who were they and how important was this?
   b. If not, do you think this would have been helpful? Why or why not? What type of mentor would have been most useful at this stage in your career?

Mentoring - Receiving
3. Do you have anyone who advises or mentors you now? If so, who?
4. Do you think it’s important to have a mentor? Why or why not?
5. What exactly would you look for in a mentoring relationship?
6. Do you think your mentor needs to be from your culture? Why?
7. Do you think your mentor has to be from your field? Why?
8. Would you like to have specific topics to discuss? How much do you think the mentor should direct such a relationship (compared to your input)?
9. What do you think of the idea of peer mentoring? What about peer groups? Would you consider that mentoring or would you label it differently?

Mentoring – Being a Mentor
10. Do you consider yourself a mentor to anybody? If so, who? How did you become their mentor?
11. If not, would you be interested in filling such a role? Why or why not or to what capacity would you be willing to mentor others?
   a. What factors influence your willingness to mentor?

Careers and Entrepreneurship
12. What are your plans for after graduation? How did you decide on this?
13. Are you concerned that it will be difficult to find a job as a female scientist/engineer? Why or why not?
   i. How are you preparing for this
   ii. Is there any way you can be helped or supported in this process?
14. Have you considered starting your own business? Why or why not?
15. What factors would lead you to become an entrepreneur either now or in the future?
16. What difficulties do you think entrepreneurs face? Are there any challenges that only apply to women?
17. Would these obstacles stop your from pursuing entrepreneurship? If no, what, if any, factors would?

Stereotyping
18. Throughout your studies, have there been any situations where you were treated differently than a male student in the classroom or during an internship?
   a. How did you react? Why?
19. In many of the focus groups it was brought up that men (classmates, teachers, in industry) tend to underestimate women. Have you ever felt like you were being underestimated?
   a. If so, when/how did you realize it was happening? How did you react? Why?
   b. If not, why do you think others stated this? Have you seen other women be underestimated?
20. Since starting at the University, have you ever doubted your own abilities? Your belonging in the field?

Final Thoughts
21. Are there any more stories/comments you would like to share about women in engineering/science in Morocco that would be useful for helping us establish a mentoring program?

Figure 4-3. Interview Script
Findings

The focus group and interview audio recordings were transcribed by the research team and were analyzed using principles of content analysis in order to identify common themes (Carley, 1990). The focus groups and individual interviews yielded a great depth of information about the experience and perceptions of women in science and engineering in Morocco. The results from both studies are presented below, addressed according to the three delineated research questions.

**What factors contribute to the “scissor effect” of Moroccan female engineers?**

During the studies, the women were asked about their future career plans in an effort to understand reasons for the loss of valuable human capital when women do not pursue SET professions. Perceived stereotyping, discrimination, tokenism, concerns about work / life balance, and internalized cultural and gender norms were all identified as contributing factors to not pursuing a SET career. The interview and focus group results helped to identify common themes and rational for the influence of these factors on the scissor effect in Morocco.

Perceived stereotyping and discrimination of women in SET fields were prevalent themes in the study. Specifically, participants reported stereotypes ranging from beliefs about physical weakness and emotions, to the commonly experienced underestimation of their intellect or work capabilities. A repeated sentiment was that, “[Men] assume you are going to be making mistakes; because you’re a girl you are supposed to be making mistakes. And if something is not going the way they want it to, you’re the one making mistakes, not the men.” Some focus group participants also noted specific instances of gender-based discrimination, citing everything from encounters verging on sexual harassment to hiring choices blatantly attempting to capitalize on expected stereotypical behavior of women. For example, one participant noted, “When a recruiter in the field recruits a woman, he recruits her because they know that when a man is fighting against her… the man will be kind to the woman so that she doesn’t cry… so they
can use the women because if the other engineer is too harsh on her she’ll start crying and he will stop and accept what she says.” In other words, the recruiter believes that if a male from another firm is ever in disagreement with the company over a service provided, then sending a female engineer to handle the interaction will lead the displeased party to accept the outcome rather than continuing to fight for what they believe they are owed because of fear of the women’s emotional reaction. Participants also shared their feelings about being a female in a male dominated industry. Specifically, interview Participant 4 stated that her female supervisor during her internship was the first female at that workplace and, “If I was [the one] there just alone… I wouldn’t really be comfortable there… When you are not really comfortable you are not ready to go and do your best.” An overwhelming male presence, whether discriminatory or not, can be threatening and may deter women who are not lucky enough to have female supervisors or coworkers. These stories reveal perceived hiring discrimination, tokenism, and stereotyping in engineering fields, pointing to lack of inclusion as a problem, but also to more concrete barriers in hiring practices in some engineering and science domains.

In addition to the perceived stereotypes and discrimination, participants noted cultural gender norms as barriers to entering and maintaining a career in SET. For example, the importance of family in Morocco was addressed several times in the focus groups with multiple participants reporting pressure to marry in their early 20s and explaining that men will often marry beneath their educational level but display an unwillingness to marry a woman more educated than themselves. Due to this, women often feel pressure from their family to forgo their education and career in SET. As one focus group participant elaborated, “You have your family telling you that you [need to] get married and you should maybe stop chasing that dream of [your career], that it’s not going to be fulfilled before reaching [your] 40s and 50s, and you’re going to… start think about letting it go.” However, of the participants who discussed marriage during the study, none indicated that the pressure to marry would stop them from pursuing their career.
A dichotomy was also revealed when domestic duties were addressed, with some women accepting cultural gender roles while others asserted that this labor division is not a mandate, merely a tradition that has been internalized through time. Interview Participant 4 openly acknowledged, “I will continue [my career], but in case of having children… I will try to stop. To have children is hard, to try to fit two things – your work and your family. You have to take care of them and it’s the big responsibility so I don’t want to take the risk and do both things at the same time.” Participant 5 mimicked this sentiment, “It’s not the fact you’re getting married. Maybe it’s the fact to have children, because you know you should take care of them, and you know all the stuff. Marriage is not the problem [for pursuing a SET career], it’s the children.” Participant 7, on the other hand, asserted, “I believe that if I choose someone to marry him, he has to be aware of that [I want to pursue a career] and to be ready to help me – even with the kids and everything.” Participant 6, who grew up with a working mother, noted that perceptions of working while raising kids may be largely related to the way that the individual was raised. Talking about her friends who grew up with stay-at-home mothers, she explained, “They just don’t imagine a working mom and how it will work.” Such patterns suggest that open conversation about balancing a family and an engineering career may be able to alter perceptions of the difficulty performing both roles well (work and family). This issue may be particularly relevant to SET careers, which tend to be time-intensive and do not easily allow for extended (years-long) hiatuses to raise children. Therefore, although all of the participants interviewed sought to pursue careers in their field of study after college, work / personal life balance appears to be a leading factor in women’s persistence in the workforce, specifically in demanding SET careers.

Finally, the underrepresentation of women in the engineering workforce may cycle back to subtle and repeated messages of cultural norms and a simple desire on the part of women or those around them to make life easier. When asked about her choice to go into engineering, one focus group participant explained, “I got a hard “no” [from my family] and I remember that I was forbidden from going outside the house for something like three months.” In her interview, Participant 7 recounted a story about her
father urging her to become an engineering professor rather than going into industry because, “For a woman, it’s good to work like a teacher… it’s the safest for you and your family.” As she described, her father, who acknowledges the intelligence and potential of women, still thinks it would be easier if his daughter took a more traditional career. A particularly detrimental consequence of repeatedly hearing such messages is the potential for internalization and a reduction of confidence in one’s ability to be successful in a SET career. As interview Participant 7 explained, “It’s sometimes the women. They are underestimat[ing] themselves, like, ‘I can’t do that. I am a woman, I can’t do that’ … You see it in the media, you see it with the teacher in the school and your parents telling you and it’s the same thing, so you get used to it. If you’re not wise enough, if you’re not critical enough, you can’t recognize that it’s not a general truth that woman should not do engineering, should not go into any career they want.”

Similarly, one focus group participant noted, “I think my challenge was me underestimating myself… I underestimated myself for two or three years and then I said, ‘What’s wrong with me?’ I can do it.”

While some participants report overcoming these messages, implicit doubts linger and may prove even more prevalent among less determined, successful women than the elite group considered here.

Overall, the focus group and interview results revealed that there are numerous factors that influence women’s persistence in SET fields, including perceived stereotypes and discrimination as well as the internalization of cultural norms that value SET as a masculine domain, both by women themselves and family. Findings also clearly indicate that family/career balance is an important consideration in women’s persistence in the engineering workforce.

What factors contribute to Moroccan women’s pursuit of technological entrepreneurial activities and what perceived obstacles exist?

In order to understand the desire for and obstacles to pursuing entrepreneurship, individual interviewees were queried. Specific benefits of entrepreneurship cited by participants included controlling their daily job activities, making their own hours, having free time, having a higher earning
potential, and determining how they contribute to society. Interview Participant 3 specifically noted that entrepreneurship might prove easier to balance work and family responsibilities, explaining, “You can just have a family and be happy. If you have something as your own, you can choose and do it as you direct.”

While five of the seven interviewees indicated no perceived gender-based differences in the challenges that entrepreneurs face, a couple interview participants challenged this notion. Specifically, Participant 6 stated, “I think people still have more faith in men than women when it comes to starting their own business and to entrepreneurs. There are a lot of successful women entrepreneurs, but [there are] more successful men entrepreneurs. They tend to have this idea that men are more responsible, they are… smarter – they think with their heads, not their hearts.” Participant 7 also recounted a story of a female entrepreneur she knew who presented her business plan to potential investors and experienced disappointment, “They didn’t say … We don’t trust you because you’re a woman… but they [did] say, we’re going to get someone who can work on that project, and that someone, he’s a man, and he’s going to have the idea, and he’s going to assist you.” Therefore, the discrepancy in the perceived presence of obstacles and discrimination may be due to differing levels of personal understanding and involvement with female entrepreneurs or may simply reflect the range of available experiences.

Four of the seven participants also indicated that they intend to eventually pursue venture creation and Participant 1 even cited an idea for an application that she is currently working to develop. As Participant 3 phrased it, “Everyone has a dream like that. It depends on the situation and if you have the idea, the money, the support, and everything like that.” All seven interviewees cited difficulties finding capital as the main obstacle that they believe entrepreneurs face. Additional factors mentioned include self- and time-management skills and the difficulty of finding trustworthy people to work with. The three interview participants who reported a plan to pursue entrepreneurship were determined and indicated that only a failure to find start-up capital would prevent them from moving forward with their projects, or, in the words of Participant 1, “I think what matters most is the idea of the project. If it is going to give back
or not, that’s what matters. I would say investments, that could be the major problem that I may have.”

Overall, the results reveal that participants perceive entrepreneurship, particularly in their field, as a worthwhile venture. Although there were mixed perceptions of the existence of gender discrimination, it was clear that procuring capital is the primary perceived challenge, and, responses suggest that engineering and technology entrepreneurship may be a possible solution to manage personal life/career balance concerns.

**How can mentoring be used to encourage women to enter the SET workforce in Morocco?**

During the focus groups and interviews, participants were asked to share their perceptions of the importance of mentorship in SET fields and discuss their current role models and mentors. A clear need for mentorship was revealed, current role models and mentors were discussed, and preferred types and styles of mentorship were indicated. Finally, current opportunities to be a mentor led to a discussion of available mentoring systems and their shortcomings. These are explained in detail below.

Overall, when asked about the desire for mentors in SET participants indicated a clear need, particularly for mentors who can understand their experiences because they are often uncertain how to proceed in their chosen career path. For example, one focus group participant stated, “We are confused a bit because it’s like we are in the middle of a cyclone… and opinions – social ones, religious ones – from different perspectives and we just feel lost. Sometimes we don’t know what we are going to do… we aren’t even sure if what we’re doing is the right thing to do or not.” Another focus group participant added, “There’s no one by your side, and so you are sometimes disappointed. Sometimes you want to just give up.” During the interviews, six of the seven participants reported that they would prefer a mentoring relationship that is friendly where conversations extend beyond work discussions: “I don’t know who the mentor would be… but the relationship, I want it to be absolutely not formal” (Participant
7). These findings highlight the importance of having a strong mentorship system, one where mentors have shared experiences and involve both career and personal mentoring. This is particularly important because lack of support may be one of the reasons women face problems in science and engineering.

Although a general lack of mentors was noted, some participants did cite instances of role models including celebrities, family members and classmates/professors. For example, one focus group participant explained that she was, “inspired by scientists… like Einstein, Newton and all their amazing works that pushed me and encouraged me, to choose engineering.” Many women also cited supportive families as the closest thing they had to a mentor, “We have role models in front of us: our parents, our cousins, our uncles.” Although many of the family members lack specific field or career-related experience, they have provided the women with guidance in hard times. Other participants cited either an older student or a professor that served as their mentor. Although several women indicated that professors are available, it was made clear that they must be sought out and the women largely did not pursue this. It is interesting to note that despite the lack of mentors within their field, all interviewees said that having a mentor is important, denoting a significant disconnect between preferences and reality. The general sentiment, as stated by Participant 6, was, “I think what lacked … [is to] have mentors they can ask and who can guide them or share experiences with them… We didn’t really have that. We’re just, like, going by luck or things we can do. We didn’t have a long term perspectives.”

Since the participants identified a need for SET mentorship, it is important to identify what the women would like in a mentoring relationship. Five of the seven women interviewed preferred to have a mentor from their field, or who knows a great deal about the type of work that they will ultimately be doing. Arguments emphasized a shared understanding and ways of thinking within specific engineering disciplines. Multiple women, however, said that they would ideally have multiple mentors so that they could receive both the benefits of specific, directed guidance and introduction to a new field and different experiences; Participant 5 stated, “I think that I [would like] two supervisors in my college, one in my field and one in statistics.” Participant 7 pointed out, “[W]hen we start launching our career, it’s not
always about [your major], it’s not always about what we took in class. It’s a general field and you go there – you use what you studied, but you use everything else that would be helpful.” Relatedly, discussions revealed that the participants viewed peer mentoring favorably. As interview Participant 2 said, “I think that peer groups can provide… friendship and also support and encouragement because they help us to access connections with people. Also, peer groups, if diverse and ambitious enough, some of them will even be able to coach you or share experience you might not have.”

Finally, it was important to consider the women’s perception of becoming a mentor to other women in the field to encourage longevity in any established mentoring program. Although only three of the seven interviewees reported currently being a mentor, all of them expressed an interest in mentoring in the future. A few participants mentioned newly created mentoring programs at their schools or departments wherein older students are paired with younger ones, but the program is not female specific. While the participants were positive about the idea, it was noted that such programs did not always work as planned. As Participant 7 said, “It worked only for a while and then we stopped.” When asked why, she explained that the organizational model may have been to blame: the mentors introduce themselves and invited them out once or twice at the beginning of the year, after which point it becomes the responsibility of the mentee to seek them out if they want assistance. Participant 7 recommended that weekly meetings might help solve this problem, as well as emphasizing to the mentee that the relationship was about more than academic work, with general life experiences also being open for discussion. This seems to mirror the broader trend of mentors being available primarily at the responsibility of the mentee. As such, a more formal matching organization structure might prove effective for professor/professional – student as well as peer mentoring relationships.

In summary, discussions revealed that there is a great desire for increased mentoring in SET fields, particularly for women who feel they are never given long-term perspectives on their choices. Women indicated that role models primarily offer inspiration, whereas mentors provide support and concrete, context-specific advice. Few women reported having mentors, and discussions indicate that the
responsibility of seeking such a relationship falls entirely on the would-be mentee, suggesting that a more formal system may prove beneficial.

Discussion & Implications

While there is an abundance of women who are well educated in SET domains in Morocco (Statistiques Universitaires 2010-2011, 2011), their ability and perseverance in finding related careers is often overcome by perceived obstacles that stand to temper their SET aspirations and ambitions. The results from this study are used to provide response strategies to support the flow of women in Morocco from undergraduate education to careers in SET, either traditional or entrepreneurial.

Stereotyping, tokenism, and conceptions of raising children and family / work balance may contribute to attrition from engineering careers

Our results revealed several factors that contribute to the reduction of female engineers after college graduation in Morocco. While the results revealed that women perceive gender-based discrimination in industry positions, it appeared to depend heavily on the specific SET field and did not seem to be the primary force decreasing women’s participation in SET careers. A larger problem may be the small number of women currently in the workplace and the discomfort of being a token minority. Such tokenism is consistent with findings that women in SET tend to feel excluded, and is likely a contributing factor to women’s lack of persistence in such fields (Henes, et al., 1995; Marra, et al., 2009). As Lent and Hackett (1987) identify, facing consistent negative stereotyping in male dominated fields and the threat of not receiving appropriate approval from valued others may negatively affect women’s self-efficacy beliefs, and therefore persistence. While exclusion and stereotyping may be a compounding factor, erosive over time, participants reported being unfazed by stereotypes and were resolved to prove their capabilities in the face of such assumptions. There was a clear belief that change will ensue if
women are given opportunities to demonstrate their capabilities. While these results provide clear insights into the perceptions of the role of stereotyping in women’s pursuit of SET careers in Morocco, future studies should be conducted to investigate the degree of exclusion and isolation experienced by women and industry and quantify the resulting effect of such tokenism.

The results of this study were also consistent with the findings of Hawks and Spade (1998) who showed that balancing work and family responsibilities was a serious obstacle to pursuing SET careers. The participants in the study noted that men are willing to marry women beneath, but not above, their educational level. This is in contrast to the United States where the percentage of “breadwinning” women in households has grown significantly, leading to a shift in marriage dynamics and perceptions of traditional gender roles (Rosin, 2012). As educated women seek careers and need not rely on men to fulfill monetary needs, a similar trend may begin in Morocco. Even as women accept new roles and challenges, however, they often refuse to relinquish power over the domestic sphere, generally maintaining the majority of child care and household duties or splitting them equally (Rosin, 2012). In fact, participants in this study stated that while marriage itself would not stop them from pursuing their career goals, children likely would. Half the women who discussed family/life balance reported that they would quit their jobs to stay home and raise children, while the other half were open to or supported the idea of being a working mother. This trend suggests that, either due to desire or societal norms, having children may account for a large portion of women’s attrition from the workforce, particularly science and engineering careers that do not readily allow for large absences. While the current study identifies the complex relationship between work and family balance, its exact relationship has yet to be teased apart due to the young, single status of the sample participants. Thus, future studies should investigate its role in order to understand how it affects a women’s persistence of engineering careers.
In the face of obstacles, engineering entrepreneurship offers a viable outlet for women’s talents

With the high unemployment rates among the educated in Morocco and North Africa (Fakim, 2012; Patel, June 2011), a primary obstacle to women joining the engineering workforce may be decision makers’ fear that by increasing female opportunities in the SET workforce those for men would be decreased; a situation that is exasperated when job openings are limited (Chamlou, et al., 2009). Therefore, while steps may be taken to support women’s efforts to pursue engineering careers, limited job availability and gender-based discrimination might prevent their employment regardless. To counter this challenge, engineering entrepreneurship was examined as a possible response strategy for increasing the number of women who pursue SET careers.

As expected, participants indicated that entrepreneurship was desirable and a considered option for them. Although studies have found that women exhibit less entrepreneurial self-confidence and perception of ability than men (Bahmani, et al., 2012; Duval-Couetil, et al., 2010), our findings suggest that women in our sample do not suffer from these problems. The women’s positive perceptions also refute El Harbi, Anderson, and Mansour’s (2009) findings that educated young people disapprove of female entrepreneurship. Despite research suggesting that entrepreneurship is a “masculine” domain (Harbi, et al., 2009; Zeffane, 2013), women were undeterred, demonstrating an enthusiasm for venture creation. Four interview participants expressed a desire to eventually pursue entrepreneurship, citing benefits including flexible hours, earning potential, and the ability to control your contributions to society. One participant stated that entrepreneurship would offer control to balance work / personal responsibilities, consistent with McGowan et al.’s (2012) assertion that this is a perceived benefit of female entrepreneurship.

The largest challenge cited in venture creation was obtaining capital, a factor that focus group participants and interviewees alike agreed upon and which is consistent with findings from an Egyptian Research Study (Farid, 2007). Cetindamar et al. (2012) identified availability of capital to be positively associated with pursuing entrepreneurship in developing countries, a trend that interview findings of this
study support. The presence of capital was cited as the most important factor determining whether an idea for a venture is pursued. Discussions indicate mixed agreement with Bahmani, et al.’s (2012) assertion that women generally face additional difficulties in capital procurement based on their gender. Although it is difficult to ensure investors and loans, steps can be taken to aid female engineers through the process. Future work should consider a quantitative approach to studying the availability of capital, particularly for technology ventures, and examining the effect of gender in an effort to resolve the currently mixed findings on the subject.

It should be recognized that our participants were selected for the initial workshop due to their interest in entrepreneurship and hailed from elite universities. Therefore, our findings may prove true only for those who consider entrepreneurship a worthwhile venture. Although participants were selected in part for their interest, it should be noted that there were ample applicants, suggesting a general interest among the population; we expect similar results would be found among a broader sample as well. Future studies should explore a wider, more diversified sample to ensure generalizability.

**Female Moroccan engineers could benefit greatly from mentoring programs**

Mentorship was also explored as a possible response strategy to the obstacles that women face in pursuing SET or entrepreneurship careers. Related work has found that women in technology fields resolve challenges, be they personal or work-related, with personal and self-driven solutions (Orser, Riding, & Stanley, 2012). Accordingly, much of the literature on women’s involvement in SET fields and male-dominated fields identifies the importance of mentors and networking (Chesler & Chesler, 2002; Chovwen, 2007; Muller, 1997; Muller & Barsion, 2003; Sengers, et al., 2008). Repeatedly hearing messages about women’s inabilities in science may negatively effect women’s confidence and, as Mau (2003) and Lent and Hackett (1987) suggest, prove detrimental to their perseverance or pursuit of careers in the field. Acceptance and support has been identified by female executives as an important factor in
satisfaction with and perseverance in traditionally male fields (Chovwen, 2007) and mentoring can help provide these tools.

Throughout the study, a clear desire and need for mentoring in SET fields was revealed. While the participants’ experience was generally limited to undergraduate education and choosing a field of study, similarly trying experiences are faced in the transition to a professional career. In the United States, it has been shown in biological and physical sciences “that both male and female faculty judged a female student to be less competent and less worthy of being hired than an identical male student, and also offered her a smaller starting salary and less career mentoring” (Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012, p. 16477). Even if the women do not internalize negative stereotypes, it becomes a constant battle for women to prove their competence; the base assumption is always that women are inferior to men, even if they have identical accomplishments. Regardless of whether the sexism is overt or implicit, it is an obstacle for women in the sciences. Mentoring relationships can help combat these stereotypes and reaffirm women’s confidence in their skills.

Women in the study acknowledged that the traditional division of labor is not a mandate, but rather a tradition that has been internalized over time. Our findings that women are expected to complete household activities is consistent with the literature (Hattab, 2012a), although our findings suggest that women may no longer accept this as a necessity. A larger issue than household duties and marriage found in our study, however, was the impact of child rearing which represents perhaps the most important point of intervention that mentoring can assist with. As was noted in the study, women who grew up with stay-at-home mothers may be unable to fathom how a woman would be able to juggle both a career and home duties. Providing mentorship from women who have accomplished this feat may provide an outlet for such discussions and influence opinions of what is possible or acceptable.

Many of the students indicated openness to the idea of less traditional mentoring formats, suggesting that mentoring between academic fields, peer, and cross-cultural mentorship could all be beneficial. Such suggestions are reminiscent of the alternative and feminist mentoring systems cited by
Chesler and Chesler (2002) and Putsche, et al. (2008). While it was mentioned that Moroccan universities are beginning to offer peer-mentoring systems, the results indicate that these systems are not yet effective. This may be due to the burden being placed on the mentee to seek out the mentor or authority figure if they want assistance or guidance – a trend mirrored in the relationships between professors and students. Placing the burden on the mentee, who may feel like the weaker party, may explain why several of the interviewed women do not currently have mentors despite citing that there are professors available to talk with.

Therefore, increasing the efficacy of mentoring networks, peer or traditional, could help combat feelings of exclusion and isolation which have been identified as a challenge to women’s perseverance in SET (Henes, et al., 1995; Marra, et al., 2009) and to address family/career balance concerns that otherwise go unspoken. Based on these finding, it is recommended that a more structured mentoring system be instantiated for Moroccan SET women. Future research should seek to implement such a system and its effectiveness for combatting the delineated obstacles and concerns.

**Future Work & Limitations**

Although this work offers important groundwork in understanding women’s perceptions of engineering and science careers, their likelihood of continuance into these fields, and the benefits of mentoring – the findings are limited by their qualitative nature because interviews and focus groups offer only subjective views of the topic. Living within a specific cultural system, it is sometimes difficult to identify problems that may be obscured by view, due either to a myopic view of a large issue or incomplete information. Future work should seek to quantify the perceptions made by participants with quantitative studies and additional qualitative reports, offering increased evidence to back the findings discussed here.
In addition, it should be noted that participants from this study were recruited from a pool of workshop participants chosen based on their entrepreneurial interest and unsurprisingly expressed positive perceptions of entrepreneurship. This tailored participant pool allowed investigation into perceived challenges and potential benefits that entrepreneurship might pose for those who are already interested in pursuing this venture and thus might not generalize as the primary obstacles to those less interested. Therefore, future studies should investigate the perception of entrepreneurship for the population at large.

**Summary and Conclusions**

The scissor effect represents a detrimental loss of (female) human capital from the Moroccan SET workforce. Findings suggest that while women do perceive stereotypes and varying degrees of discrimination and tokenism in male-dominated SET workplaces, equally formidable threats to women’s representation in engineering careers may be the prospect of raising children and internalization of societal gender norms. Many participants suggested that although marriage would not stop them from working, raising children would. Participants expressed positive perceptions of female entrepreneurship, indicating that engineering entrepreneurship represents a viable option and may offer a flexible alternative that would allow for better time management of family and work responsibilities. All interviewees cited lacking capital as the primary problem they perceive in pursuing entrepreneurship; accordingly, educational opportunities for women in venture creation and capital procurement are recommended.

This work has shown that Moroccan female engineers express a clear desire and need for SET mentorship and guidance. Based on the findings, a formal mentoring program, particularly between industry professionals and students, is recommended as a way to encourage persistence through the transition from university to SET industry; as a strategy for offering long-term perspective and may decrease attrition due to concerns about family/work balance and other concerns. Future work should
investigate implicit bias and structural factors that may not be perceived by individuals within the culture, as well as working to offer more quantitative results to support the reports made.


UNESCO. (September 2010). Women's and girls' access to and participation in science and technology *Expert group meeting on gender, science and technology* (pp. 1-13). Paris, France: United Nations Division for the Advancement of Women (DAW, part of UN Women).


Authors

Samantha P. Adams is a master’s student in the Department of Industrial and Manufacturing Engineering at Penn State University; 259 Leonhard Building, University Park, PA 16802; spa129@psu.edu.

Dr. Scarlett Miller is an assistant professor of Engineering Design and Industrial Engineering at Penn State University, College of Engineering; 213-P Hammond Building, University Park, PA 16802; scarlettmiller@psu.edu.