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كلية محمد بن راشد للإدارة الحكومية
MOHAMMED BIN RASHID SCHOOL OF GOVERNMENT


# Persistence in the Abu Dhabi STEM Pipeline

## PREPARING EMIRATI YOUTH FOR SCIENCE AND TECHNOLOGY CAREERS IN THE INNOVATION ECONOMY

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# Foreword

A culture of innovation within society can lead to sustained economic growth, greater global competitiveness, enhanced employment and entrepreneurship opportunities and a more inclusive society for youth.

As the world gets to grips with the digital revolution, helping young people to navigate the associated complexities and opportunities becomes critical. The UAE has taken a leadership role in this space with various nation-wide initiatives aimed at promoting innovation and creativity within all sectors. More needs to be done, however, to build a core talent pool of youth with expertise in Science Technology Engineering and Mathematics (STEM).

Our work with the private sector has clearly highlighted that while national efforts to bring young talent into STEM roles in the business world are gaining ground, there is still a lack of supply given the country's ambitious industrial development plans. From aviation to solar and renewable energy to downstream industries, the UAE has powerful potential to create regional economic opportunity and drive innovation through science.

As the national foundation of the UAE and with its focus on youth development, Emirates Foundation is committed to accelerating this process and has developed a comprehensive STEM program called Think Science.

Think Science aims to inspire young scientific talent to consider science as both a study and a career option by showcasing the employment opportunities they could potentially gain. The program provides young scientists with skills and knowledge to meet the growing needs of industry while also nurturing their personal and professional development.

Equally it helps private sector companies interested in STEM talent showcase their employee value proposition and access a pool of relevant and high quality young Emiratis. Our annual Think Science Fair, run under the patronage of the Foundation's Chairman H.H Sheikh Abdullah bin Zayed Al Nahyan, Minister of Foreign Affairs, consolidates this work and secured 13,000 participants in 2015.

Our work with the Mohamed Bin Rashid School of Government (MBRSG) could not, therefore, have been more timely or more relevant. As the UAE prepares to further develop and deploy STEM talent, there is a need for data and a detailed understanding of the current situation and future scenarios.

We are delighted to have been able to partner with MBRSG to this effect and believe that this work will provide substantive and unique insights into how the STEM challenges of the UAE can be further addressed and how the enormous opportunity of youth STEM talent can be maximized. We encourage others to read and share the outcomes of this report with a view to further building on the opportunity for innovation in the United Arab Emirates.

**Clare Woodcraft-Scott**
Chief Executive Officer of Emirates Foundation

# *Preface*

*"Innovation today is not an option but a necessity, not a general culture but business style. Governments and companies that do not renew or innovate lose competitiveness and control. They are bound to regress"*

–H.H. Sheikh Mohammed bin Rashid Al Maktoum

Innovation has long been heralded as the cornerstone of any successful economy. At the core of any development is the disruption that innovators cause to the accepted ways of doing things. The cycle of innovation and disruption is fueled by innovators. Innovators are individuals who are not only made of knowledge, creativity, and passion, but also of persistence.

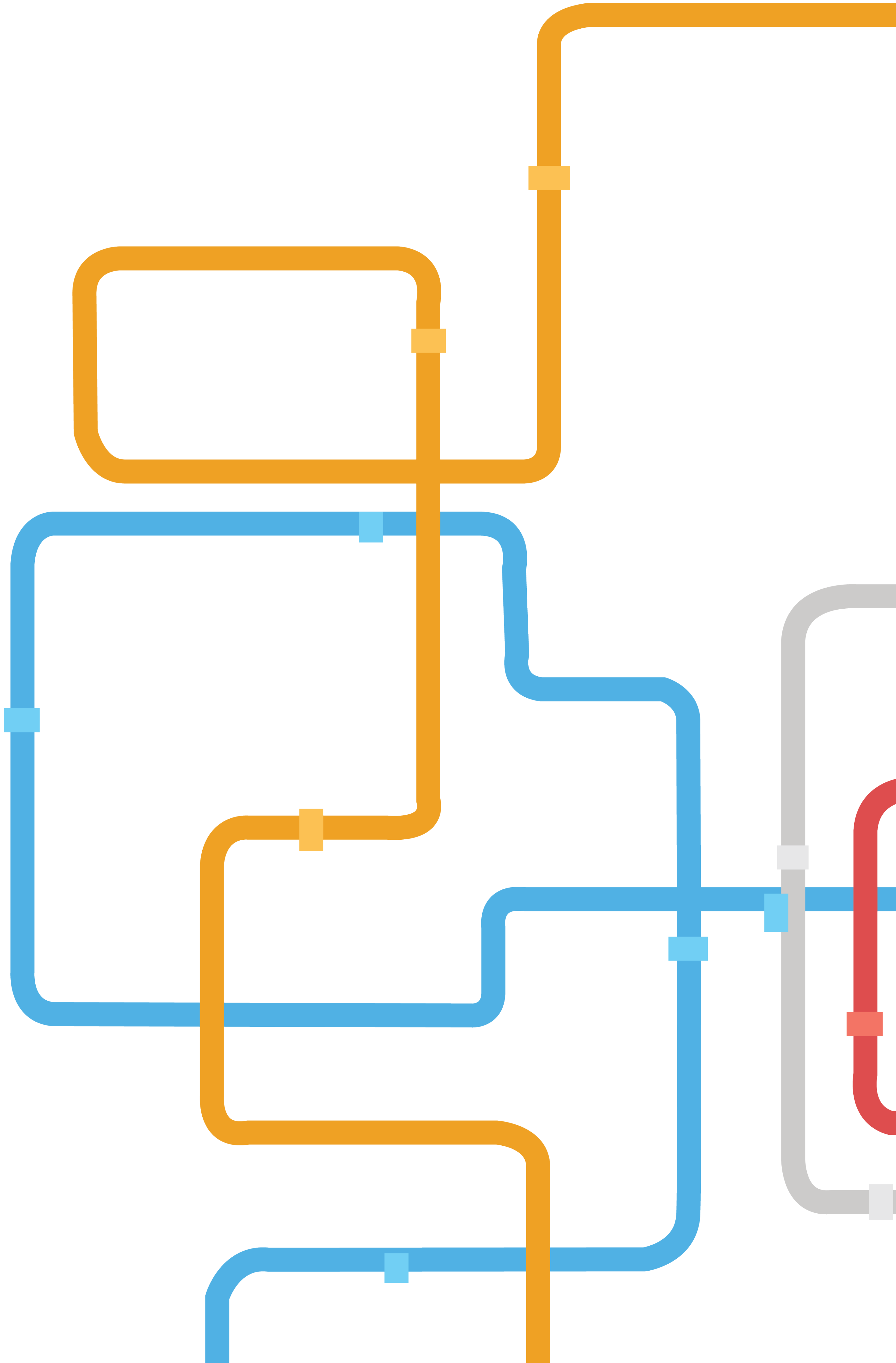
Today's world economy is much more open and transparent than it ever was. Fierce global competition means that countries are running an innovation race, and the countries that can innovate better will undoubtedly win. Factors influencing innovation are many. However, at the core of innovation are individuals who have the necessary skills and attitudes to make remarkable positive difference.

The connection between innovation and human capital is undeniable. In this knowledge and innovation economy, the greatest resource a country has is its workforce. In order to achieve the United Arab Emirate's ambitious goals special attention must be paid to building a strong work force that is able to tackle the challenges of the day. Issues as the need for alternative energy sources, food scarcity, and water scarcity require a work force that is well trained in engineering, chemistry, biology, and environmental science. Having a well equipped STEM workforce is no longer an option for any country.

This report was prepared in collaboration with the Emirate Foundation and presents a view of the factors influencing Abu Dhabi Emirati students' choices to pursue STEM education and careers. The aim of this report is to inform policy makers and practitioners in order to develop policies, programs, and initiatives that will enable and support Emirati students to become the innovators that the country needs.

We thank the Emirates Foundation for their initiative and generous support. We hope that this report will be of good use to all concerned.

**Dr. Raed Awamleh**
Dean of the Mohammed bin Rashid School of Government



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# EXECUTIVE SUMMARY

This report aims to investigate the leaks in the STEM pipeline among Emiratis in Abu Dhabi. The government of Abu Dhabi's ambitious plans for the future necessitate a skilled and committed STEM workforce and so, understanding why talented Emirati students are not filling the ranks of engineering, science, and technology jobs is of utmost importance. To that end, the Mohammed bin Rashid School of Government, in collaboration with the Emirates Foundation, conducted an exploratory study among school and university students in Abu Dhabi to understand the factors that influenced their choices to enter into STEM fields.

Secondary school curriculums in the emirate of Abu Dhabi have been reformed to focus more on STEM subjects. Reforms announced in 2015 will eliminate science and humanities tracks for students in Abu Dhabi. Abu Dhabi currently has 8 universities. In 2013, the total number of students enrolled in university in the emirate was 50,754. 25.9% of graduates from UAEU in 2013 were in humanities and social science majors. 21% came from management and economics majors. The lowest percentage of graduates (3%) were from medicine and health sciences majors.

## *Selected Findings*

### High School Survey

**Encouragement from parents teachers and peers:** In general, students reported that they received encouragement from parents, teachers and peers to pursue STEM. Correlation analysis indicated that there was a significant relationship between students' reports that they received encouragement from teachers and the likelihood that they entered a STEM track in high school.

**Science identity:** When students were asked if they considered themselves a "science person", 61% agreed. Correlation analysis indicated that there was a significant correlation between self-reported science identity and students' intentions to pursue STEM university majors.

**Interest in math and science:** students were asked if they found math and science interesting and 80% reported that they did find math and science classes interesting. Correlation analysis indicated that there was a significant correlation between student interest in STEM and their intention to pursue STEM majors in university.

**Confidence:** Students were asked if they thought that they were were good at math and science and 88% said that they were. Correlation analysis indicated that there was a significant correlation between student perception of ability in science and math and student intention to pursue STEM majors.

**Perceived value of STEM education:** By and large, the majority of students seem to perceive STEM skills as valuable and STEM knowledge as necessary for success in life. Correlation analysis indicated that there was a significant relationship between the positive perception attached to the value of STEM and the intention to enroll in STEM majors.

### University Survey

**Institutional support:** 78% of respondents agreed that they had some form of institutional support. However, there was considerable variation between the kinds of support they were offered. There was no correlation between institutional support and student intention to pursue STEM careers.

**Career support:** When asked if they received support in finding STEM internships and part time work, 57% of students said that they did. While these resources exist, their effectiveness varies. Only 31% of students were assisted with interviews by their career offices and only 35% found internships through these offices.

**Attitudes toward the STEM labor market:** By and large STEM students believed that jobs in the STEM labor market are of high quality (83%), and are highly available (85%). 88% were optimistic about finding jobs in that market. When asked if they felt prepared to enter the STEM job market, 89% reported that they did indeed feel prepared. Correlation analysis showed that attitude toward the quality and availability of STEM jobs was significantly correlated with students' intentions to pursue STEM careers.

**Student satisfaction with university education:** By and large, students were satisfied with the quality of their STEM education, though satisfaction with career opportunities and guidance was markedly lower than satisfaction with instructors and curricula. There was a significant correlation between student satisfaction and attitudes toward the STEM labor market

**Gender differences:** There was a minor difference between the percentage of females that wanted to find STEM jobs (84%) and males who wanted to do so (71%). However, correlation analysis indicated that gender had a significant correlation to intention to pursue a career in STEM.

# INTRODUCTION

As global competitiveness rises and as the need for innovation and knowledge economies becomes more urgent, countries all of the world have turned their attention to science and technology education to solve the innovation stagnation. Globally, there is a crisis in the STEM labor market whereby the demand for STEM professionals is higher than the supply. As such, many have begun to ask: where are the leaks in the "STEM pipeline", and why do they exist?

STEM refers to Science, Technology, Engineering and Mathematics. The path from STEM high-school education to a STEM university education and then to a STEM career has been analogized as a pipeline. At the start of their high-school education, students choose whether to pursue science or math subjects. In some cases, they decide whether they will enter a science track or a humanities and social science track. This choice is understood as attrition into the pipeline. From there, students must choose whether they will go to university and if so, whether they will continue on to higher STEM studies. This is referred to as retention in the STEM pipeline. More importantly however, these students must then make the choice to continue on to STEM careers. Within the pipeline analogy, when a student chooses to stop pursuing STEM education, or chooses not to enter the STEM labor market, there is a leak in the pipeline.

This report aims to investigate the leaks in the STEM pipeline among Emiratis in Abu Dhabi. The government of Abu Dhabi's ambitious plans for the future necessitate a skilled and committed STEM workforce and so, understanding why talented Emirati students are not filling the ranks of engineering, science, and technology jobs is of utmost importance. To that end, the Mohammed bin Rashid School of Government, in collaboration with the Emirates Foundation, conducted an exploratory study among school and university students in Abu Dhabi to understand the factors that influenced their choices to enter into STEM fields.

In the first section of this report, we will utilize theories and studies to explain the accepted reasons for why students choose to "do" STEM and the reasons why they drop out. Next, we will give a brief overview of the status of the STEM pipeline in the emirate of Abu Dhabi. In the second section of this report, we will discuss the results of two surveys that were conducted among Emirati school and university students between September 2014 and August 2015. In the final section, we will offer recommendations for strengthening the STEM pipeline in Abu Dhabi.

# Attrition and retention in the STEM pipeline

Concern over the strength of the "STEM pipeline" originates from the consensus that a healthy and competitive economy requires a thriving innovation sector. While the innovation sector is in need of professionals from all backgrounds, science, engineering, math and technology professionals make up its backbone. Beyond economic competitiveness, global warming, food and water shortages, and an energy crisis have created a need for dedicated researchers and applied scientists able to work on long term solutions.

Strengthening the STEM pipeline requires long term plans that are based on evidence gleaned from research into the causes of attrition and retention in STEM fields. To begin this discussion, we must first understand what we mean by a STEM pipeline.

## *What is the STEM pipeline?*

Researchers often refer to students' trajectories from high school to university and then to the STEM labor market as movement through a pipeline. The pipeline is usually depicted as narrowing (getting smaller in diameter) as students move through its junctures. The junctures symbolize milestones and as students move through them, some of them leak out, thus leaving us with an image of a leaky pipeline. This image is based on evidence that strongly suggests that more students enter STEM tracks in school than pursue STEM majors in university. Similarly, more students pursue STEM university majors than enter the STEM labor market.

Based on this metaphor, researchers and policy makers are invited to ask why these leaks exist, what the characteristics of those who leak out are and how the leakage can be stopped (Cannady et.al, 2014).

While the pipeline metaphor is the most common way that researchers and policy makers have thought about progression through STEM education and careers, it is not the only way to think about these issues. In fact, the linear manner in which it depicts education and career progression has been criticized by many academics (Cannady et. al, 2014; Xie and Shauman, 2003; Metcalf, 2010; Xie and Killewald, 2012).

Cannady et. al (2014) argue that the pipeline metaphor is an insufficient framework through which to assess STEM career trajectories. The STEM metaphor, according to Cannady et. al suggests that (1) each milestone in the pipeline is necessary and (2) that passing all of the milestones is enough to enable and qualify students for entry into a STEM career (p.445). This, they argue, opens up the metaphor to a number of important critiques, namely that it suggests that the "career trajectory [of a scientist or engineer] has one inlet, one outlet, and one direction of flow" (p.445). This poses some unique problems. First, a focus on only those who have successfully flowed through the pipeline leads researchers to focus on characteristics that any STEM professional will typically have, such as a STEM bachelor's degree. A focus on only those who succeed in passing through the pipeline leads to a kind of self-fulfilling prophecy. The characteristics then become too broad and do not distinguish between those who become scientists and engineers and those who do not. Second, in an effort to make these characteristics more specific, researchers use regression analyses to identify predictive variables that lead to STEM careers. As such, these researchers identify milestones that are good predictors of future STEM degrees and jobs but ignore the fact that many STEM professionals do not satisfy all of them. And so, the satisfaction of all of these milestones ignores the characteristics of a considerable proportion of STEM professionals. The pipeline assumes that experiences are uniform and that milestones alone are sufficient to lead to STEM careers. It focuses on the completion of milestones and does little to understand the motivations of students and the impact of quality of education, barriers to access and other context based sociocultural factors (Cannady et. al, 2014).

This critique is the reason why, while we use the pipeline metaphor, our focus is not on the milestones, but rather on student desires and intentions to continue on in STEM careers. Our recommendations are based on enabling students rather than on prescribing milestones that they must pass on their way to a STEM career. We are cognizant and sensitive to the fact that, for most people, career progression is not linear and that context matters. In many ways, STEM career progression should not be thought of independent of issues in education, life/ work balance and access to resources in general. As such, we follow the logic that has been put forth by theorists such as Mazlow (1943), White (1959) and Deci and Ryan (1985), that suggests that intrinsic motivation and the ability and desire for competence and self-actualization is what drives individuals to pursue certain education and career goals over others. We pay special attention to sociocultural factors and barriers to entry that result from gender dynamics and language attainment.

## *What retains students in the STEM pipeline?*

There are several theories that have been utilized to explain the educational and career choices of individuals. Choices have been theorized as the result of socio-economic factors such as class, and gender (Ball et al. 2002; Bourdieu and Passeron 1990; Meece et al., 2006). Other approaches have focused on motivation and include effectance motivation (White, 1959), achievement motivation (McClelland, Atkinson, Clark, and Lowell, 1953), self-efficacy theory (Bandura, 1977), and intrinsic and extrinsic motivation theory (Ryan and Deci, 2000). Here we will discuss three important theories that seek to explain the impact of attitudes and values on student motivation, the relationship of "science identity" to retention, and the impact of structural and resource factors on student success.

### *Expectancy – value theory*

Many studies relating to STEM retention and achievement have utilized expectancy – value theory to explain student motivation to continue in the

STEM pipeline (Tighezza, 2014; Bøe and Henriksen, 2013; Bøe and Henriksen, 2015; Flake et al., 2011; Wang and Eccles, 2013; Wang and Degol, 2013).

Expectancy value theory is a theory developed by Eccles and Wigfield (2000) that argues that choice, persistence and achievement in a particular activity can be explained by a student's beliefs in their own ability to be successful at it and the extent to which they value that activity. The Eccles et al. framework predicts that students will choose courses that (1) they think they can succeed at and (2) they believe are valuable. The model is divided into subjective task value and expectation of success. Subjective task value can then be subdivided into (a) interest-enjoyment value, (b) attainment value, (c) utility value and (d) relative cost. According to Eccles (2009), students' beliefs about their own identity and their expectation of success, and the value they attach to educational options determines the likelihood that they will decide to pursue them. Subjective values that are attached to STEM courses or pursuits are impacted by cultural context and by the external messages students receive about the value of STEM.

Expectations for success are impacted by both students' perceptions of their own ability to be successful at STEM, but also on their perceptions of the difficulty of STEM subjects and how much effort and time is required to pursue them. These aspects are also impacted by socio-cultural factors. For example, the stereotype that women are bad at math may lead young women to have a low expectation of success at math. Additionally, the perception that one either has "it" (the ability to be good at math and science) or not impacts students' perceptions about their competence in these subjects. These aspects of the model are impacted by the encouragement that young people receive from teachers and parents that may lead them to believe that with enough practice they will be able to master these subjects.

## *Science identity models*

Science identity theories have become much more prevalent as a lens through which to understand student motivation to pursue STEM education and careers. The identity lens, it is argued, provides a unique way in which to view the process of learning and the ways in which a student's perception of themselves mediates that experience. As such, it also is able to shed light on how marginalized populations, such as women and ethnic minorities, might experience science learning and the ways in which cultural factors promote certain kinds of "scientists" over others. It claims that students will pursue science if it is aligned with their own view of who they are.

Here we will discuss two identity constructs developed by Carlone and Johnson (2007) and by Brickhouse et al. (2000) and Brickhouse and Potter (2001). Brickhouse and Potter (2001) developed their identity construct through their study of girls' participation in science. They understand identity as being a student's "understanding of herself in relation to both her past and potential future" (966). Brickhouse et al. (2000) argue that identity is neither single nor stable and that an individual may hold or aspire to be a part of several communities simultaneously. For this reason, science identities must be understood in the context of students' other identities (for example: class, gender, and nationality). Ideals of what scientists are and ought to be can lead to either engagement or disengagement from science depending on how narrow and enduring these ideals are. Based on this, students make choices about what groups they belong to, what groups they wish to belong to and what work is required in order to achieve that. Carlone and Johnson (2007) argue that a student must recognize them self as a scientist and be recognized as such in order to pursue science. Because recognition as a legitimate "science person" is a part of science identity construction, social and cultural factors play a big part. In order to be recognized as scientists, students must demonstrate their competence, interact with others that belong to that group, and perform well in STEM.

Taking these two frameworks together, it becomes important to understand science identity as being the result of intrinsic and extrinsic factors and to acknowledge the importance of positive confirmations of identity and access to relevant communities of practice. It also makes the construction of science identities that marginalize certain kinds of students (for example, the view of scientists as old, white, males) a focus of study.

## *Trilogy for success*

The trilogy for success, or the ECC trilogy, is a framework that was developed by Eric Jolly, Patricia Campbell and Lesley Perlman and consists of three factors: (1) engagement, (2) continuity and (3) capacity. The popularity of this framework can be attributed to the fact that it includes both individual and structural factors.

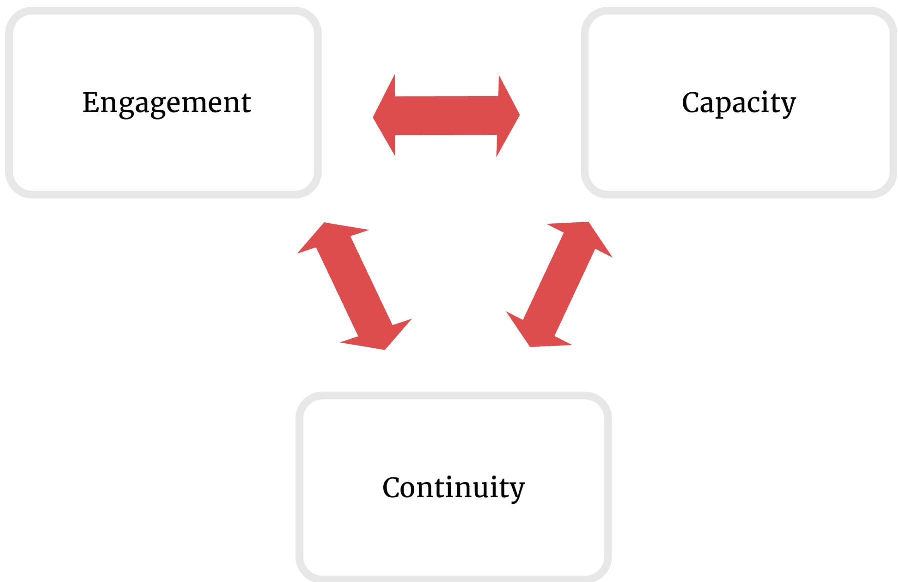


Fig 1. Trilogy of Success/ ECC Trilogy as depicted in Jolly et al. (2004)

Jolly et al. (2004) developed this trilogy as a result of investigations into projects and programs that succeeded at improving student achievement in STEM. The themes that resulted from these investigations fell into three broad categories as depicted above. According to this framework the three factors that are necessary for student success in STEM are:

**Engagement:** this refers to the factors that draw (or engage) students in the study of STEM subjects and consists of (1) positive involvement in academic, social and extracurricular activities, (2) positive attitudes toward the study of STEM, (3) commitment to master the discipline, and (4) a positive view of STEM professions

**Capacity[1]:** refers to the fundamental knowledge and skills necessary to becoming a STEM professional and consists of : (1) knowledge of facts, terminology, and methods of dealing with discipline specifics, (2) comprehension of materials, (3) ability to apply previously learned knowledge to new situations, (4) deconstructing information, understanding organizational structure of information, and developing alternative conclusions, (5) applying prior knowledge in creative ways so as to produce a new product or idea, (6) ability to evaluate the value of material based on personal views and resulting in a product "with a given purpose and without real right or wrong answers" (Jolly et al., 2004, p. 7)

**Continuity:** refers to systematic and structural access to necessary information, resources, and skills. It consists of: (1) high quality, advanced core curricula in STEM that is available to all students regardless of income, race, ethnicity, or gender, (2) college guidance, counseling, preparation and information resources which are made available to all students without discrimination, (3) access to extracurricular STEM programs and activities, (4) high teacher quality and capacity.

This study utilizes some aspects of all of the theories presented here. While we did not seek to confirm or challenge any of these accepted frameworks, we tried to create a broad and holistic method of inquiry that aimed to understand the impact of values and attitudes, identity, capacity and resources on student intention to continue in the STEM pipeline.

1. Jolly et al. develop the measures for "capacity" using Bloom's taxonomy.

# STATUS OF THE PIPELINE IN ABU DHABI

While the true shortage of qualified scientists in other economies, such as that of the United States, has been debated (Xie and Killewald, 2012), the shortage of Emiratis in the UAE STEM work force is a widely accepted fact. The country's goal to increase participation of Emiratis in the workforce in general, and its goal to create a robust knowledge and innovation economy are intertwined. In order to achieve both of these goals, more Emiratis need to become prepared to enter the innovation workforce. While the country and the government of Abu Dhabi has taken concrete steps to provide more high quality STEM education, this alone does not guarantee that students will go on to become productive STEM professionals. By and large, a lower proportion of Emiratis choose to study STEM subjects in university than do choose to study business. Below, we take a look at the status of the STEM pipeline in Abu Dhabi and examine this shortage more closely.

## *STEM Education in Abu Dhabi*

### *High school education*

The Emirate of Abu Dhabi has 265 public schools[2] . After kindergarten, students go through three cycles of education (1) Cycle 1: grades 1 – 5; (2) Cycle 2: grades 6–9; (3) Cycle 3: 10–12. As of 2014, there were 31,829 Emirati students in grades 9-12. 24,805 were in public schools (78%). Among all students, nearly 50% are female, making the female to male school enrollment ratio 98.4 .

Secondary school curriculums in the emirate have been reformed to focus more on STEM subjects . Reforms announced in 2015 will eliminate science and humanities tracks for students in Abu Dhabi. However, before these reforms, students were required to choose a science or humanities track in high school. After the implementation of these reforms, students will be able to study the same unified curriculum until their graduation. These reforms ensure that students are exposed to STEM subjects all through their high school careers.

### *University Education*

The Emirate of Abu Dhabi currently has 8 universities (2 government and 6 private) and 19 higher education institutes. In 2013, the total number of students enrolled in university in the emirate was 50,754. Of those, 27,595 were attending government institutions. 25.9% of graduates from UAEU in 2013 were in humanities and social science majors. 21% came from management and economics majors. The lowest percentage of graduates (3%)

2. Information regarding the school system in Abu Dhabi was gathered from the ADEC website. https://www.adec.ac.ae/en/Education/OurEducationSystem/PublicSchools/Pages/default.aspx

were from medicine and health sciences majors.

## *The state of science and math literacy in the UAE*

The PISA (2012) study that was conducted in the UAE in 2012 assessed the math and science capabilities of 15 year olds in the UAE against their counterparts in other countries in the world. The UAE ranked 48th (out of 65) in mathematical literacy. In comparison to OECD countries, the UAE measured 60 points lower than the OECD average. It was found that UAE students were more proficient in applying mathematical methods than interpreting and reflecting on problems and then finding solutions. With regard to science literacy, the UAE ranked 44th (out of 65). Students in the UAE scored low points for problem solving skills, scoring 89 points below the OECD average[3] .

These capabilities are reflected in larger STEM trends in the UAE whereby only 19% of students in private universities, and 21% in government universities were enrolled in STEM majors. Of the students who are enrolled in STEM majors, 31% were studying engineering. Only 0.61% of students in government universities were enrolled in the natural sciences. Additionally, only 16% of all Emirati females and 35% of males entered STEM majors[4].

3. Please see UAE PISA report for more information.
4. All statistics can be found in the UAE Statistics Center or Abu Dhabi Center for Statistics websites

# Explaining the leaks in the Abu Dhabi STEM pipeline

*The Study*

# THE STUDY

This study is exploratory and so, our initial goals were broad in nature. First, we wanted to understand what leads high school students to intend to pursue STEM subjects after graduation. Second, we tried to understand what leads university students to intend to pursue STEM careers after graduation. More specifically, we wanted to understand:

1. Do environmental, social factors such as parental, teacher and peer encouragement impact student attrition into the STEM pipeline (i.e. choosing a STEM track in high school)?
2. Does awareness of role models impact high school students' intentions to pursue a STEM university degree?
3. Do attitudes toward the value and utility of STEM impact high school students' intentions to pursue a STEM university degree?
4. Does interest in STEM subjects impact high school students' intentions to pursue a STEM university degree?
5. Does a "science identity" impact high school students' desire to pursue STEM university degrees?
6. Does engagement in STEM activities outside of school impact high school students' intentions to pursue a STEM university degree?
7. Does self-confidence and a sense of preparedness impact high school students' intentions to pursue a STEM university degree?
8. Does gender impact high school students' intentions to pursue a STEM university degree?
9. Does institutional support in STEM studies impact university students' intention to pursue STEM careers after graduation?
10. Does career support impact university students' intention to pursue STEM careers after graduation?
11. Do attitudes toward the STEM job market impact university students' intention to pursue STEM careers after graduation?
12. Does a sense of preparedness for the STEM job market impact university students' intention to pursue STEM careers after graduation?
13. Does gender impact university students' intention to pursue STEM careers after graduation?
14. Does English language acquisition impact high school and university students' retention in the pipeline?

## *Research methodology*

In order to answer these questions, the Mohammed bin Rashid School of Government and the Emirates Foundation ran two bilingual surveys among students in Abu Dhabi high schools and universities. The high school survey ran between September 2014 and February 2015, and the university survey ran between September 2014 and August 2015. The high school student survey consisted of 45 questions that asked students about their interest in STEM subjects, their awareness of STEM offerings and opportunities, their teacher, peer and parental encouragement, role models, exposure to STEM in the media, perceived value of STEM subjects, and barriers to pursuing a STEM university education. The university student survey consisted of 38 questions and asked students about the factors that contributed to their pursuit (or not) of STEM majors, their satisfaction with their STEM education, institutional support for STEM studies, factors contributing to their desire to pursue STEM careers, and the kinds of STEM careers they want to pursue.

To supplement the findings of our surveys, we conducted 3 focus groups. One focus group was conducted with industry recruiters in STEM fields. This focus group focused on the challenges facing recruiters as they try to attract and retain Emirati STEM professionals. The group consisted of recruiters from the following companies: Totale, British Petroleum ME, Siemens, Masdar, Etisalat, Sharjah police, and Borouge. Another 2 focus groups were conducted with university students in Abu Dhabi and aimed to further understand the contextual factors that impact students' choices to enter into STEM fields. The first focus group consisted of four students in a mechanical engineering department, the second consisted of two students in the natural sciences, specifically biology and bio-chemistry. All of the students who volunteered and attended our focus groups were women.

## *Survey Samples*

This study consisted of two distinct samples, one of high school students and the other of university students.

### High School Student Survey

Respondents to this survey consisted of high school students ranging from the 9th to 12th grades. STEM and non-STEM students were surveyed. Most, but not all, questions were answered by both STEM and non-STEM students. Some questions were answered only by STEM students, while others were answered only by non-STEM students. The survey was disseminated to high school students in all public and private schools in Abu Dhabi. We received responses from all nationalities and then isolated those respondents who were Emirati. 869 Emirati students responded to our survey, and, of those, 741 were STEM students. All respondents included in this study completed the survey in full. Some students completed the survey at home while others completed it at school. In all cases, the survey was conducted online. The completion rate among students in Abu Dhabi was 100% i.e. all students who started the survey completed it. The number of respondents of all nationalities was 1062.

### University Student Survey

The university student survey was conducted among university students in private and public universities across Abu Dhabi. STEM majors as well as non-STEM majors were surveyed. As with the high school student survey, we received responses from all nationalities but isolated those respondents who were Emirati. The completion rate for this survey was 16% percent, i.e. only 16% of students who started the survey completed it. The total number of respondents for this survey was 371 and of those, 323 were Emirati. Of those, 187 were STEM majors. Most, but not all, questions in the survey were answered by both STEM and non-STEM majors.

The majority of the respondents to our university survey were women. This is representative of the gender make up of universities in Abu Dhabi. By and large, the majority of students in university are female. Even within the sciences, women still make up the majority of students.

## *Measures*

### High School Student Survey

A. **STEM interest:** this was measured using two items that asked students about their interest and enjoyment of math and science subjects.

B. **Perceived utility of STEM:** this was measured using 7 items that interrogated students about the value of STEM knowledge and skills. Among them were questions about its value for their future careers, civic life, and life in general. Students answered on a Likert scale.

C. **Perceived social cost of pursuing STEM:** this was measured using two items that asked students about whether they believed that pursuit of STEM subjects will reduce their ability to make friends or find spouses in the future.

D. **Perception of STEM as a tool to achieve national goals:** this was measured using one item that asked students if they thought that studying STEM will enable them to participate more actively in achieving the nation's goals.

E. **Confidence in STEM ability:** this was measured using 3 items that asked students if they believed they were good at math and science, if they have succeeded in math and science in the past, and if they believe they would succeed at math and science if they pursued it in the future.

F. **Science identity:** was measured using a single item in the survey that asked students if they thought that they were a "science person". Answers were measured on a Likert scale.

G. **Engagement in extracurricular activities:** this was measured using two items that asked students if they were enrolled in STEM extracurricular activities and whether they formed STEM study groups with peers outside of school.

H. **Encouragement:** for this, three forms of encouragement were measured (1) encouragement from parents, (2) encouragement from teachers, (3) encouragement from peers. Questions for this measure tried to assess the external messages students received regarding success in STEM, STEM capacities, and the value of STEM.

I. **Awareness of science role models:** This was measured using 5 items that asked students if they were aware of foreign, Arab, Emirati, male and female STEM role models.

J. **Gender:** this was measured using one item that asked students about their gender.

K. **Attrition into the STEM pipeline/ choice of STEM track:** this was measured using one item that asked students if they were enrolled in a STEM track or if they were taking STEM related subjects in school.

L. **Intentions to pursue STEM education in university:** this was measured using one item that asked students if they intended to pursue STEM majors in university.

### University Survey

A. **Institutional support:** this was measured using one item that asked students whether STEM students at their university received adequate institutional support.

B. **Career support:** two forms of career support were measured: (1) university career support in the form of career offices and (2) career fairs. Students were asked if they visited career offices and fairs and if they found them useful.

C. **Attitudes toward STEM job market:** this was measured using three items that asked students about whether they believed that STEM jobs were of high quality and available, and if they felt optimistic about finding a job in the STEM job market. Students responded on a Likert scale.

D. **Satisfaction with STEM education:** this was measured using 7 items in which students were asked about their satisfaction with their curricula, instructors, facilities, extracurricular activities, caliber of their peers, and career guidance. Students responded on a Likert scale.

E. **Confidence in preparedness for the STEM job market:** this was measured using one variable in which students were asked how prepared they felt they were to enter the STEM job market. Students responded on a Likert scale.

F. **Gender**: this was measured using one item that asked students about their gender.

H. **English language fluency:** this was measured using one item in which students were asked about their level of fluency in English.

G. **Intention to pursue a STEM career:** this was measured using one item that asked students if they intended to get a STEM related job after graduation.

## *Data analysis*

Research questions and their respective measures were identified and coded. After the data was coded and combined into relevant variables, correlation analysis was conducted using SPSS.

Correlational analysis was used as a statistical technique that can illustrate whether and how strongly pairs of variables are related. The main result of a correlation is called the correlation coefficient (or "r"). It ranges from -1.0 to +1.0. The closer r is to +1 or -1, the more closely the two variables are related. If r is close to 0, it means that there is no relationship between the variables. If r is positive, it means that as one variable gets larger, the other gets larger. If r is negative, it means that as one gets larger, the other gets smaller (often called an inverse correlation).

# Explaining the leaks in the Abu Dhabi STEM pipeline

## *Results of the high school student survey*

# HIGH SCHOOL STUDENT SURVEY FINDINGS

## *Demographics*

***Demographic Profile of the Sample***

N=869

| Variable | N | Percent |
|---|---|---|
| **Nationality** | | |
| Emirati | 869 | 100% |
| Non-Emirati | 0 | 0% |
| **Gender** | | |
| Female | 530 | 61% |
| Male | 339 | 39% |
| **School Type** | | |
| Private | 254 | 29% |
| Public | 615 | 71% |
| **School Track** | | |
| Science Track | 412 | 47% |
| Humanities and Social Sciences | 78 | 9% |
| No Track but Takes STEM Subjects | 329 | 38% |
| No Track but Does not Take STEM Subjects | 49 | 6% |
| **Grade Level** | | |
| Grade 9 | 262 | 30% |
| Grade 10 | 288 | 33% |
| Grade 11 | 191 | 22% |
| Grade 12 | 128 | 15% |
| **English Proficiency** | | |
| Native | 61 | 7% |
| Fluent | 368 | 42% |
| Intermediate | 401 | 46% |
| Beginner | 38 | 4% |
| **Language of Instruction** | | |
| English | 778 | 90% |
| Arabic | 90 | 10% |
| **Intention to go to University** | | |
| Yes | 714 | 82% |
| No | 22 | 3% |
| Unsure/ Haven't decided | 132 | 15% |

***Science Student Sample***

N=741

| Variable | N | Percent |
|---|---|---|
| **Gender** | | |
| Female | 474 | 64% |
| Male | 267 | 36% |
| **Intention to Study STEM in University** | | |
| Yes | 571 | 77% |
| No | 170 | 23% |

Table 1. Demographic Profile of High School Student Survey Sample

## *Encouragement from parents, peers and teachers*

Because, for many students, enrollment in a STEM track or STEM courses in high school is a requirement for entry into STEM university majors, students were asked about their experiences with encouragement before the 9th grade. Students were asked if they were encouraged to explore STEM subjects, if they were rewarded if they succeeded in STEM subjects, and if they were told that with enough practice they can succeed at STEM. These questions were meant to gauge the degree to which students were provided with positive messages about STEM and their abilities in STEM, as well as whether they were recognized for their achievements in these subjects. In general, students reported that they received encouragement from parents, teachers and peers to pursue STEM. When asked if they were encouraged to pursue STEM subjects, a higher proportion (67%) of students received encouragement from parents than from teachers (43%), or peers (33%).

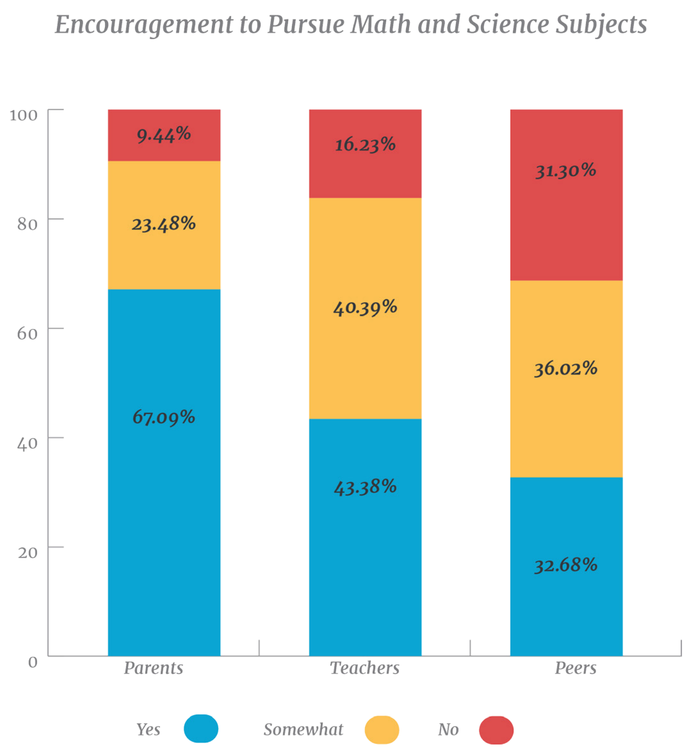


Fig. 2 Students who received encouragement from parents, teachers and peers to pursue STEM subjects as a percent of total respondents.

Correlation analysis indicated that there was a significant relationship between students' reports that they received encouragement from teachers and the likelihood that they entered a STEM track in high school ($r=-0.88$). Similarly, a significant relationship was identified between students' reports that their parents encouraged them to pursue STEM and their enrollment in STEM tracks (r=-.116). Finally, encouragement from peers also showed a significant correlation with enrollment in STEM tracks (r=-.085).

When we tested the correlation between encouragement and the likelihood that students would report that they felt that they are a "science person", we found that there was a significant correlation between encouragement from parents (r=.325), teachers (r=.253), and peers(r=.299) and science identity. Encouragement was also significantly correlated with students' reports of interest in STEM. Parental encouragement (r=.260), teacher encouragement (r=.303) and peer encouragement (r=.369), all impacted student identity.

This indicates that the positive messages students receive about their ability to pursue STEM and positive confirmation of their competence in the subject influences their later choices to pursue science tracks in high school. Students' perceptions of their ability in STEM as well as their legitimacy as "science" people is significantly impacted by whether they are told they are able to succeed in these subjects and rewarded when they do.

## *Science identity*

When students were asked if they considered themselves a "science person", 61% agreed (38% = strongly agree and 23% = agree). Of the students who were enrolled in science tracks in high school, 65% agreed to the statement "I consider myself a science person".

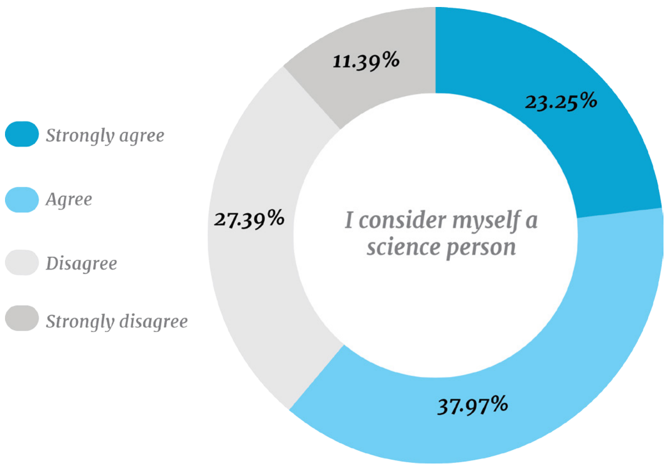


Fig 3. Students who consider themselves a "science person" as a percentage of total respondents.

Correlation analysis indicated that there was a significant correlation between self-reported science identity and students' intentions to pursue STEM university majors (r=.287). Additionally, there was a significant correlation between students' positive perceptions of their ability in STEM and science identity (r=.494). Students who reported being engaged in extracurricular activities were also more likely to report being a "science person" (r=.287).

These results suggest that students' perception of themselves as belonging to a community of "science people" who are different from other students impacts their intentions to persist in science after graduation. In addition to encouragement and recognition from teachers and parents, students' perceptions of their own abilities in science and math influences whether they perceive themselves as a "science person". Engagement with peers who are interested in science outside of school (through study groups and extracurricular activities) also influences a student's perception of themselves. This is line with theories of science identity that claim that a student must be recognized as a science person, display competence in the subject and engage with others within a community of practice to successfully form a science identity.

## *Interest in STEM subjects*

Students were asked if they found math and science interesting and 80% reported that they did find math and science classes interesting. Students were also asked if they would enjoy math and science classes if they were to take them or continue to take them. 76% (27% = strongly agree and 49% = agree) indicated that they would enjoy them. Among students enrolled in a STEM track, 82% indicated that they enjoyed math and science.

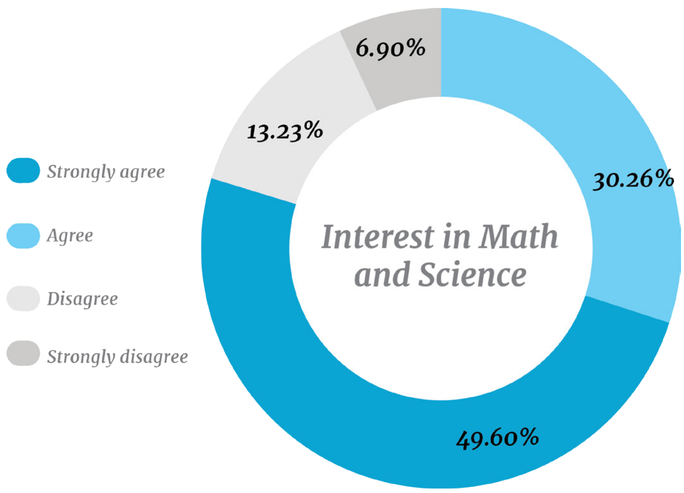


Fig 4. Students who reported being interested in math and science as a percentage of total respondents.

Correlation analysis indicated that there was a significant correlation between student interest in STEM and their intention to pursue STEM majors in university (r=-.303). This indicates that student enrollment in a science track may not be enough to predict their persistence in the STEM pipeline. Instead, the degree of interest and engagement with the subject matter may be a stronger indicator. This has a significant bearing on how STEM curricula should be designed.

## *Confidence and perception of competence*

Students were asked if they thought that they were good at math and science and 88% (59% = agree and 29% = strongly agree) said that they indeed thought they were good at math and science. Of those students who were in a science track, 90.71% (60.43% = agree and 30.28% = strongly agree) agreed that they were good at math and science. This number was also high for students who were enrolled in humanities and social science tracks whereby 71.65% of them reported being good at math and science. Similarly, when asked if they have succeeded in math and science in the past, 85% of humanities and social science students said that they had. Among science students, 95% said that they had succeeded in math and science in the past. It should be noted that while these numbers are extremely high for both groups, a smaller percentage of students said they were good at math and science than those who reported having succeeded at them in the past. These high percentages may also signal that students' choice to enroll in math and science tracks may be the result of many interrelated factors of which ability is just one.

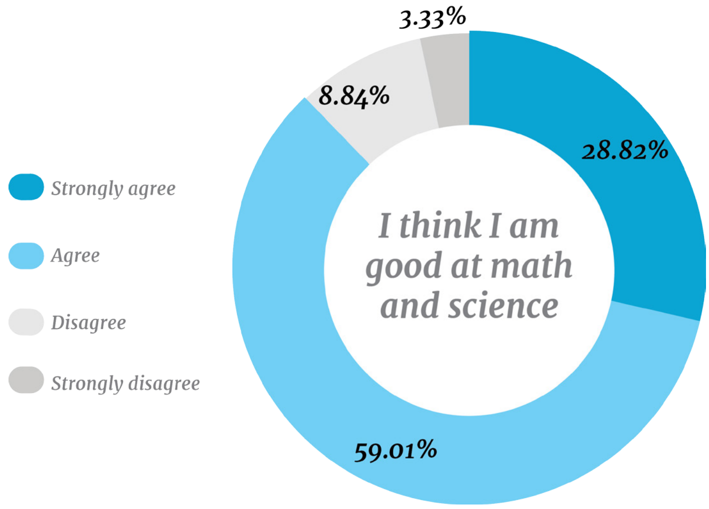


Fig 5. Students' perception of their own competence in STEM as a percentage of all respondents.

Correlation analysis indicated that there was a significant correlation between student perception of ability in science and math and student intention to pursue STEM majors at a university level (r=.229). Students who perceived themselves as competent in these subjects were more likely to report an intention to pursue STEM in university. This is in line with theories on STEM participation that claim that competence, as well as a student's perception of their own competence, are necessary for persistence in the STEM pipeline. However, this alone is not enough to predict or ensure that students will continue in the sciences.

## *Perceived value and prestige of STEM*

Students were asked a number of questions regarding their perception of the value of a STEM education. By and large, the majority of students seem to perceive STEM skills as valuable and STEM knowledge as necessary for success in life. When asked if every Emirati ought to have an understanding of math and science 83% of all students agreed. Of the science students, 84.5% agreed. This number was also high among humanities and social science students whereby 73% of them agreed that every Emirati should have science and math knowledge. Furthermore, when asked if they thought that math and science was valuable, 91% of respondents said that it was. In terms of relative significance, when students were asked if they thought that performing well in math and science was more important than performing well in the social sciences, 75% said that it was. Even among art students, 61% (39% = agree and 22% = strongly agree) agreed to that statement. This leads us to conclude that, in general, students see math and science as being of high value.

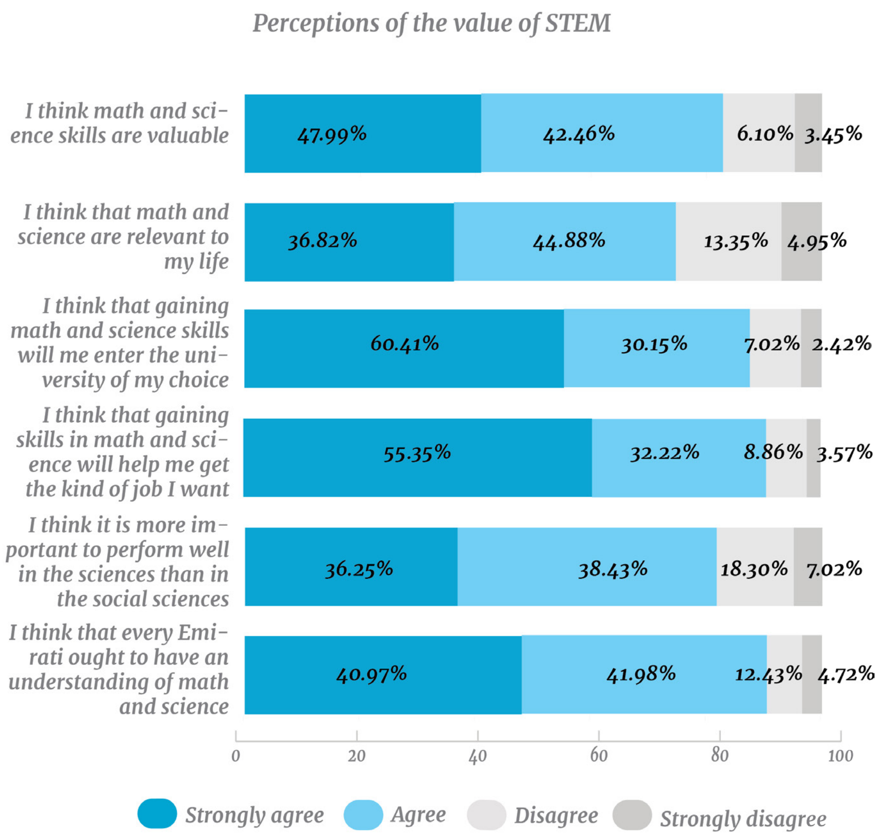


Fig 6. Students' perception of the value of STEM as a percentage of all respondents.

With regard to perceptions of the prestige and status attached to STEM careers, students had similarly positive responses. When asked if they thought people who work in STEM ought to be respected more than people who work in others fields. 36% answered yes. Even among humanities and social science students, 31% believed that STEM careers ought to be more respected. Furthermore, when asked if they thought STEM careers were more prestigious, 48% of respondents said that they thought they were. This again indicates that attitudes toward the sciences are overwhelmingly positive. Despite this fact, students are not entering these fields at a rate that is reflective of these attitudes. This may be owed to the cost attributed to these careers. While students clearly thought that STEM jobs were more respectable and valuable than other jobs, they also viewed them as requiring more hard work (50%).

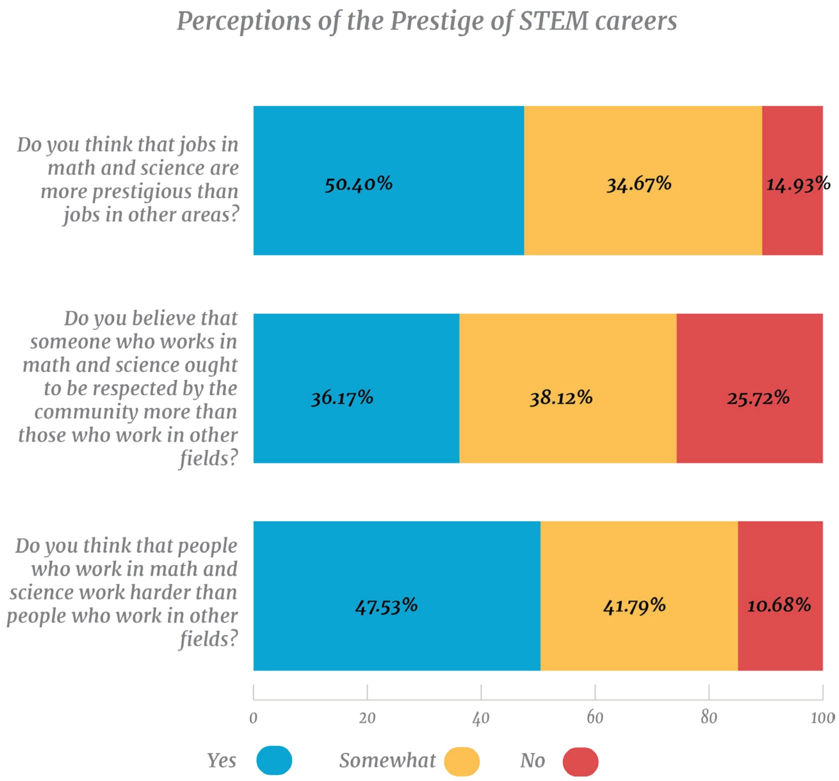


Fig 7. Student perceptions of the prestige attached to STEM careers as a percentage of all respondents

Correlation analysis indicated that there was a significant relationship between the positive perception attached to the value of STEM subjects and the intention to enroll in STEM majors in university (r=.350). Similarly, positive perceptions of the prestige of STEM careers had a significant correlation with the intention to pursue STEM majors in university (r=.225). This is again aligned with the literature on persistence in the STEM pipeline that argues that the perception of value is a major indicator of whether students persist in STEM or not.

## *Perception of social cost*

Evaluation of the worthiness of the pursuit of STEM requires students to think of, not only the benefit of STEM careers and knowledge, but also of the costs attached to their pursuit. To gauge their attitudes toward the social cost of pursuing STEM, we asked students about how worthwhile they thought the time they spent studying STEM was, if they would choose to spend time on STEM over other endeavors, and if they believed that they would lose friends, or spouses as a result of following STEM career paths.

When asked if they thought that time spent learning math and science was time well spent, 84% of students agreed that it was. When asked if they thought that learning math and science was worth the effort, 91% of students agreed that it was. When asked if they thought that studying math and science was more worthwhile than studying humanities and the social sciences, 77% said that it was. While the number is lower among humanities and social science students (59%), the majority of them believed that, had they had the choice, math and science would be a more worthwhile pursuit.

However, even if students thought that the pursuit of STEM was worthwhile, they thought that it had social consequences. When asked if studying math and science will reduce their ability to make friends, 48% agreed that it would. Among humanities and social science students, this number rises to 53%. When asked if they thought that studying math and science would reduce their ability to find an appropriate spouse, 37% said that it would. This number rises to 39% among humanities and social science students.

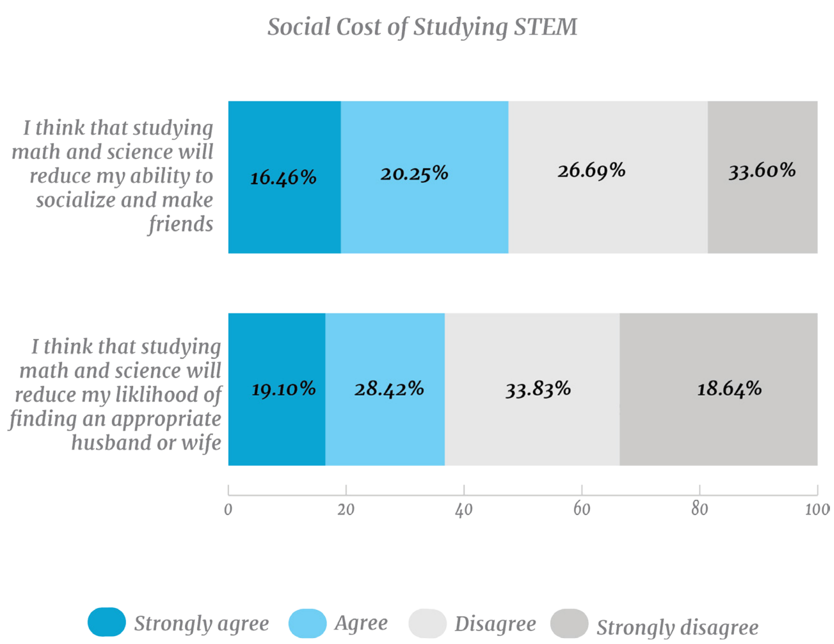


Fig 8. Perception of the social cost of studying STEM as a percentage of all respondents.

Once again, it is obvious that, by and large, students perceive STEM studies as a worthwhile endeavor. However, it is also perceived as having a high social cost. Correlation analysis done on this variable, however, indicated that there was no significant correlation between the perception of social cost and the intention to pursue STEM in university (r=-.019).

## *Perception of STEM as a tool to achieve national goals*

Perception of the study of STEM as a tool to achieve national goals can be viewed as an extension of perceptions of the value of STEM studies. When asked if they were aware of the UAE's goals to become an innovation economy, 99% of students responded that they were indeed aware. When asked if they believed that participation in math and science will help them to fulfill the UAE's goals, 74% said yes.

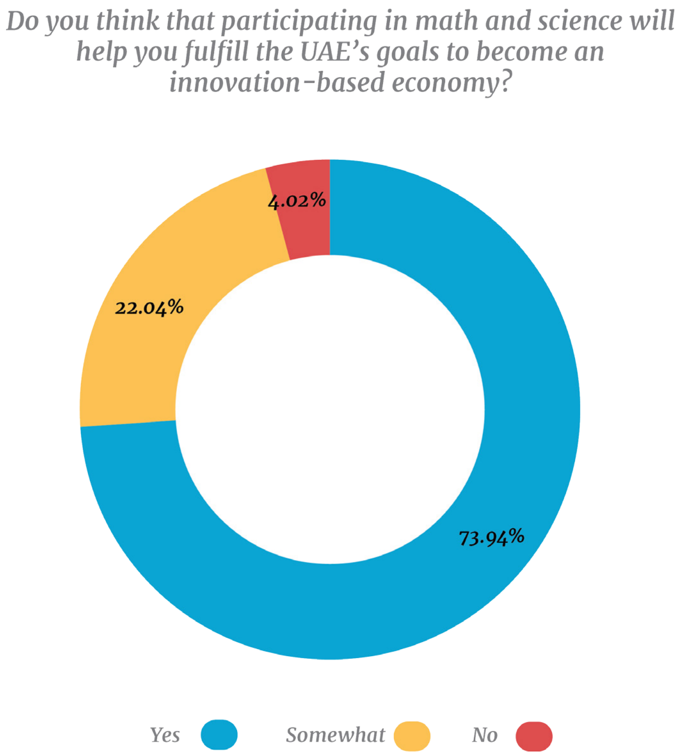


Fig 9. Perception of STEM as a tool to achieve national goals as a percentage of total respondents.

Correlation analysis indicated that both the awareness of UAE's goals to become an innovation economy (r=-.073) as well as students' belief that their participation in STEM would enable the achievement of these goals (r=.265) were significantly correlated with students' intentions to pursue STEM university majors.

## *Extra-curricular activities*

When asked if they were enrolled in math and science related activities outside of school before the 9th grade, only 26% of respondents said that they were. However, when asked if they organized STEM related study groups with friends, 42% of respondents said that they did. Among science track students, the percentage of students enrolled in extracurricular STEM activities before the 9th grade was also 26%.

There is a significant correlation between student enrollment in STEM extracurricular activities and their enrollment in a science track in school ($r=-.076$). Additionally, there was a strong correlation between student engagement in extracurricular activity and self-reported science identity ($r=.287$). This indicates that engagement with peers with similar interests allows students to build science related identities. Additionally, while participation in extracurricular activities is only one aspect of engagement, it has a significant effect as it may allow students to cultivate competence and encourage independent pursuit of mastery in the discipline.

## *Role Models*

An important aspect of external messages about "who does STEM" are the role models that students are exposed to. When we asked students if they were aware of any STEM role models who were foreign, 35% said that they were aware. When we asked the same question about Emirati roles models, only 23% were aware of any. When we asked if they were aware of female role models, 22% reported being aware.

Correlation analysis indicated that there was a significant relationship between the awareness of role models (combined awareness of all kinds of role models) and student intention to pursue STEM majors in university ($r=.141$). When we tested if awareness of female role models had an impact on the intention of female students to enroll in STEM majors, we found that there was a significant correlation between awareness of female role models and the intention of female students to persist in the STEM pipeline. This is aligned with the literature that argues that students are more likely to persist in STEM if their personal identities are in line with who they perceive scientists to be. It follows, then, that the more exposure students get to scientists with whom they can relate, the more they are likely to see an alignment between their identities and the identity of a "scientist".

Awareness of STEM Role Models

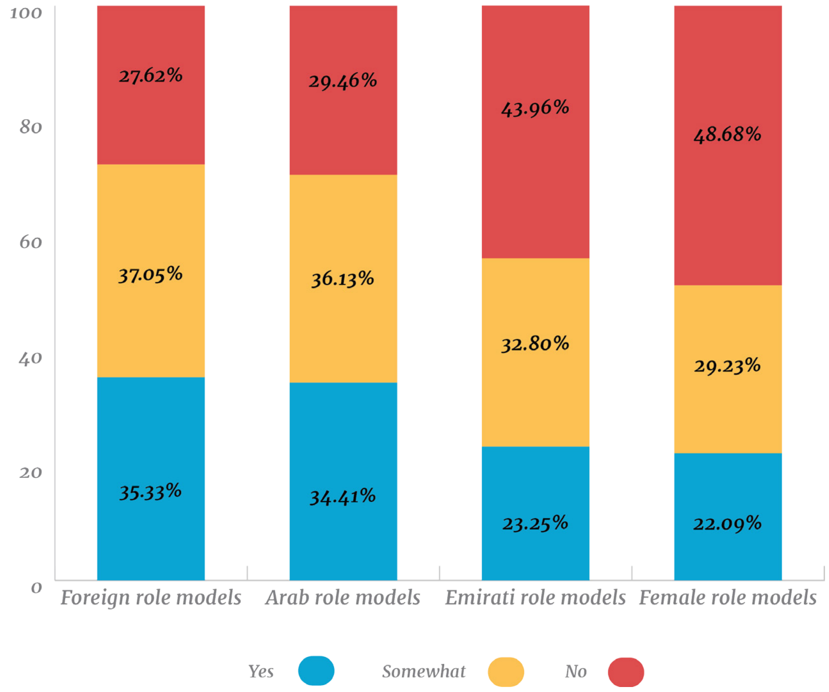


Fig 10. Student awareness of role models as a percentage of all respondents.

## *Gendered perspectives toward STEM education*

When asked if they intended to pursue STEM majors in university, an almost equal percentage of girls (79%) as of boys (74%) said that they intended to do so. Similarly, boys and girls valued STEM studies and perceived them as highly important. However, there were some differences in the ways that boys and girls perceived the social cost of the pursuit of STEM. A larger percentage of boys (55%) than girls (43%) thought that studying STEM would reduce their ability to make friends. Similarly, a larger percentage of boys (53%) than girls (26%) thought that pursuing STEM studies would negatively impact their ability to find an appropriate spouse. This may be due to the fact that STEM subjects are viewed as highly masculine and dominated by men. As such, more boys than girls may see positive interaction with the other sex as diminished due to immersion in these fields.

When asked if they were told that science and math was equally suited to boys and to girls, by and large, students were told that STEM subjects were equally suited to both genders. However, 18% of students reported that, among their peer groups, they were told that math and science were better suited to boys than to girls. More humanities and social science students (23%) said that they were told science was more suited to boys than did science students (17%).

Correlation analysis indicated that at the high school level, gender was not significantly correlated with intention to pursue STEM subjects in university (r=-.069).

## *Conclusions*

By and large students had a very positive outlook with regard to STEM education. Both science track and humanities/social science track students viewed STEM education favorably. This may be due to the increased national interest in STEM education and the launch of multiple ambitious and important STEM initiatives on the national level (such as the Emirati space program). Furthermore, there was a perception that those who study STEM work harder than others, give up social privileges (such as friendships and appropriate spouses), and are deserving of more respect than people in other fields. While students clearly have a very high opinion of STEM, their participation in STEM education is not reflective of this. And so, we need to understand what other factors may influence these choices.

If we think about these attitudes within the framework of expectancy-value theory, it is clear that students attach a high value to STEM, but this value is moderated by their perception of the effort and time required to "do" STEM. Additionally, these values and cost-benefit analyses are mediated by student identities. Student identity has shown to be strongly correlated to students' intentions to pursue STEM educations in university. Our research indicated that science identities are impacted by students' perceptions of their abilities, as well as by their interest in STEM subjects. Furthermore, exposure to appropriate role models, and subsequently students' abilities to align their own identities with that of a "scientist", may decide the way that students think of the value of STEM in context. This indicates that while there needs to be a focus on curricula and on student acquirement of necessary skills, attention also needs to be paid to teacher competence, teacher attitudes, and extra-curricular activities. It is not enough for students to perceive STEM as important, but rather they must be enabled to build science identities through effective role modeling, extra-curricular activities, and an encouragement of science centered communities of practice, even at a junior level.

# Explaining the leaks in the Abu Dhabi STEM pipeline

*Results of the university student survey*

# UNIVERSITY STUDENT SURVEY FINDINGS

## *Demographics*

***Demographic Profile of the Sample***

N=323

| Variable | N | Percent |
|---|---|---|
| **Nationality** | | |
| Emirati | 323 | 100% |
| Non-Emirati | 0 | 0% |
| **Gender** | | |
| Female | 230 | 71% |
| Male | 93 | 29% |
| **Type of University** | | |
| Public | 238 | 74% |
| Private | 85 | 26% |
| **University Major** | | |
| STEM related | 168 | 52% |
| Not STEM Related | 136 | 42% |
| Used to be a STEM Major | 21 | 6% |
| **English Proficiency** | | |
| Native | 12 | 4% |
| Fluent | 163 | 50% |
| Intermediate | 143 | 44% |
| Beginner | 7 | 2% |

***Science Student Sample***

N=187 (Including former STEM majors)

| Variable | N | Percent |
|---|---|---|
| **Gender (students currently in STEM)** | | |
| Female | 125 | 73% |
| Male | 43 | 25% |
| **University Major** | | |
| Medicine | 8 | 4% |
| Pharmacology | 1 | 1% |
| Biology | 8 | 4% |
| Chemistry | 4 | 2% |
| Physics | 1 | 1% |
| Mathematics | 6 | 3% |
| Computer Science | 24 | 13% |
| Environmental Science | 12 | 6% |
| Engineering | 101 | 54% |
| Other | 22 | 12% |
| **Intention to Find a Job** | | |
| Yes, I want to find a STEM job in the private sector | 38 | 20% |
| Yes, I want to find a STEM job in the public sector | 107 | 57% |
| Yes, I want to find a job in a non-STEM related field | 26 | 14% |
| No, I do not want to find a job | 16 | 9% |
| **Industry of Choice** | | |
| Biomedical/Life Science | 13 | 9% |
| Chemistry | 4 | 3% |
| Physics | 1 | 1% |
| Math | 7 | 5% |
| Engineering | 64 | 44% |
| Forensic Science | 1 | 1% |
| Computer Science | 28 | 19% |
| Environmental Science | 18 | 13% |
| Other | 8 | 6% |

Table 2. Demographic Profile of University Student Survey Sample

## *Factors influencing choice to study STEM*

When students were asked about what factors most influenced their choice to enroll in STEM majors in university, 67% reported that interest in STEM subjects was a contributing factor. 53% chose a STEM major because they thought there was a need for STEM majors in the labor market. 52% reported choosing a STEM major because they felt it would be beneficial to society, and 49% did so because they thought it would allow them to help the UAE achieve its national goals. 47% thought that pursuing STEM would make them a better Emirati. This data is line with the conclusions we arrived at from the high school student survey. Interest in STEM and the perception of its utility were significantly correlated with student intention to persist in the STEM pipeline. Here again, we saw that the most cited reason for pursuing a STEM major was interest in the subject matter followed only by perceptions of the usefulness of such a major for society or for achieving national goals.

*Factors that Contributed to Student Enrollment in STEM majors*

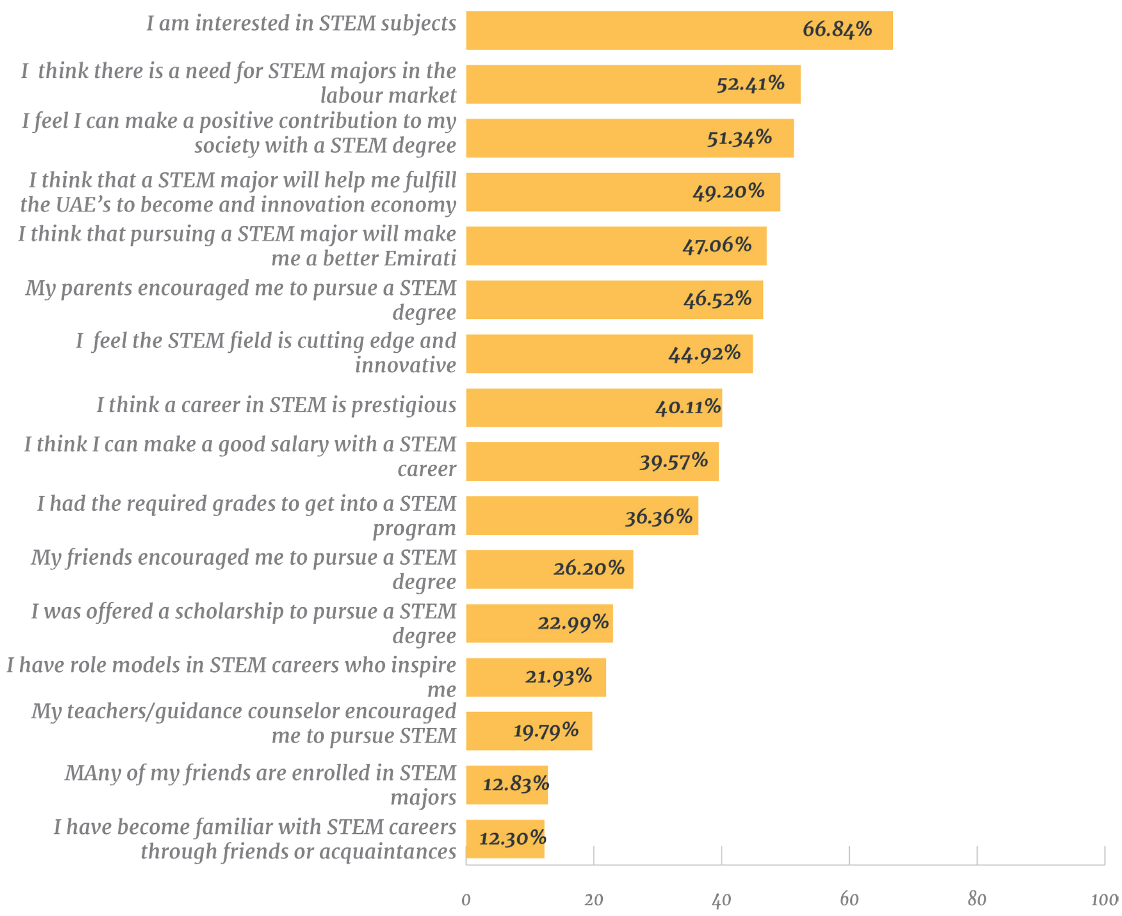


Fig 11. Factors that contributed to student enrollment in STEM majors, as a percentage of total number of students in a STEM major

INDUSTRY PERSPECTIVES

*Many students enter into STEM fields in UAE universities already sponsored by certain companies. While this does not account for all students, industry representatives reported that, in their experiences, students are sponsored from when they start their university education at the age of 17 or 18. While this is a great recruitment strategy for those that do the sponsoring, industry professionals wondered whether it was helpful for market competition. Putting this information within the science identity and interest framework, these sorts of sponsorships, if they are not followed up by mentorship, contact with the sponsoring entity, and adequate encouragement of science interests, can lead to a deterministic attitude towards one major and a sense that one is bound to continue with in it because they have been sponsored.*

## *Institutional support*

In order to understand the context in which students are choosing whether they intend to pursue STEM careers, we asked students about the kind of support they receive from their university institutions. 78% agreed that they had some form of institutional support. However, there was considerable variation between the kinds of support they were offered. 50.27% of students said that their universities had a well equipped lab and facilities. However, this percentage changed depending on students' majors. 67% of biology students said they had well equipped labs, 55% of engineering students said the same, while no mathematics or physics students indicated that their universities had well equipped labs.  27% of students indicated that their universities offered tutoring in STEM subjects. 37% of engineering students said they received tutoring support, only 16% of biology students said the same, and 31% of computer science students had tutoring support. Focus group interviews indicated that, while these supports may exist, the level of utilization by students might still be low. Focus group participants reported that their tutoring office, while available, often over-burdened and not useful. Instead, many students opted for peer to peer tutoring whereby students with "high GPAs" tutored students who needed assistance. Additionally, while labs were well equipped, not all students always had appropriate access to labs. Some students indicated that their labs were high tech but were not equipped for the number of students in the program.

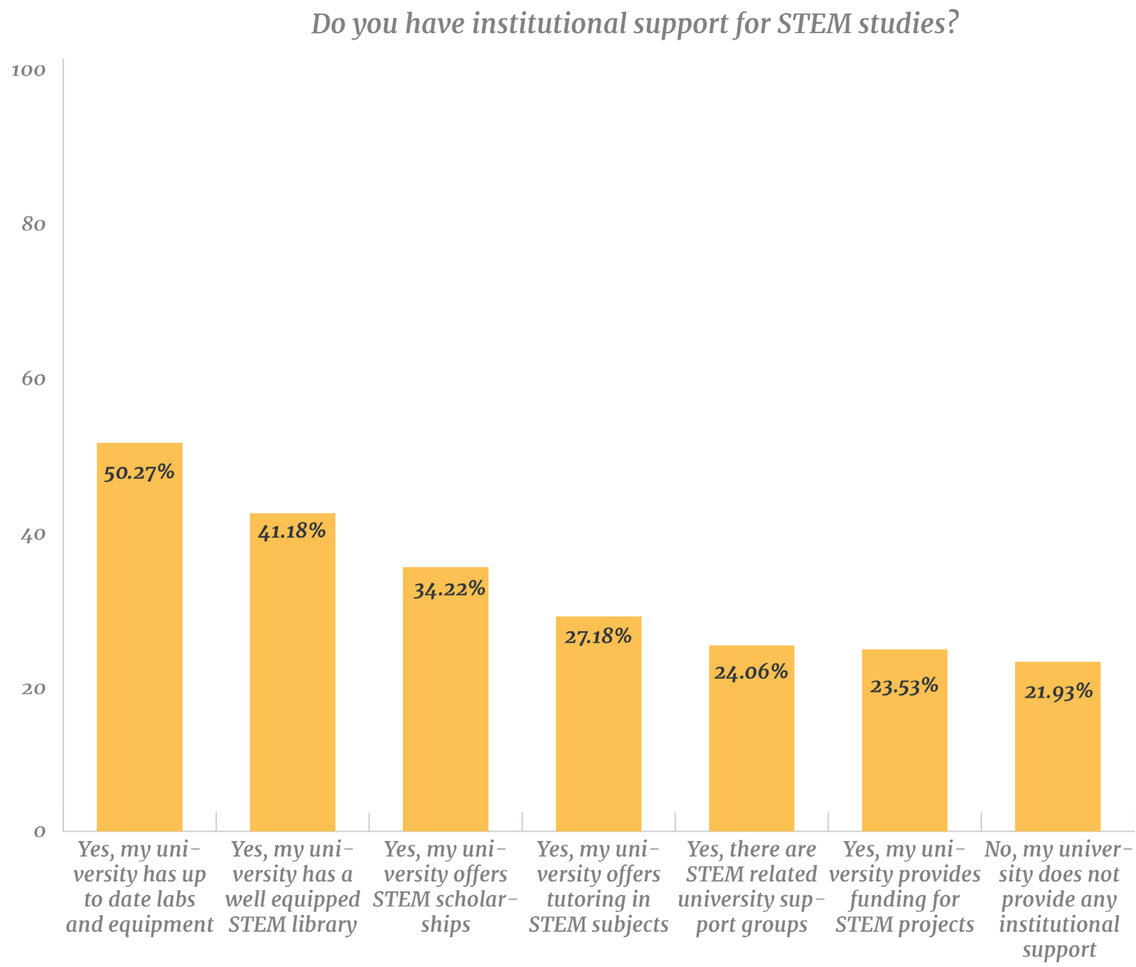


Fig 12. Students who have institutional support for STEM studies as a percentage of total STEM majors.

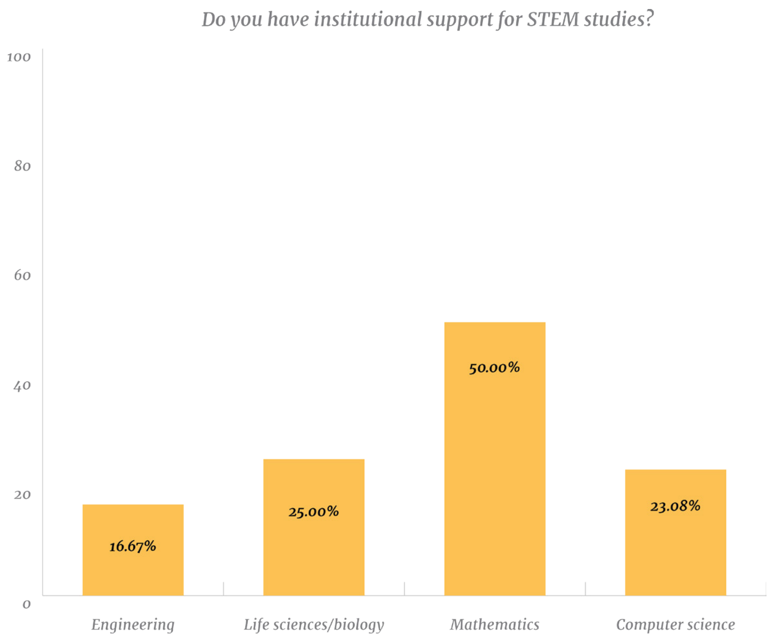


Fig 13. Students who said they had no institutional support by major.

Correlation analysis indicated that there was no significant correlation between whether students reported having institutional support for STEM (r=-.002) and student intention to carry on in a STEM field. This may be because of the variation in experience. While students reported that support existed, focus group data indicated that the degree to which they had access to it, believed it was effective, or utilized it, varied.

## *Career support*

When asked if they received support in finding STEM internships and part time work, 57% of students said that they did. Of the engineering students, 61% said that they did receive support in finding internship opportunities. However, this differed by major and so, only 17% of all biology students reported the same, and 0% of mathematics students said that they did. When asked if they visited a career office or career fair, 74% and 70% respectively said that they had. Only 20% of students agreed that career fairs helped them to network with STEM employers. 38% said that career offices helped them with their job search. However, in both cases, over 40% agreed that career offices and career fairs increased their awareness of the STEM labor market. As with other support resources, their existence is distinct from the ways in which they are used and are found to be useful. While these resource exist, their effectiveness varies. Only 31% of student were assisted with interviews by their career offices and only 35% found internships through these offices.

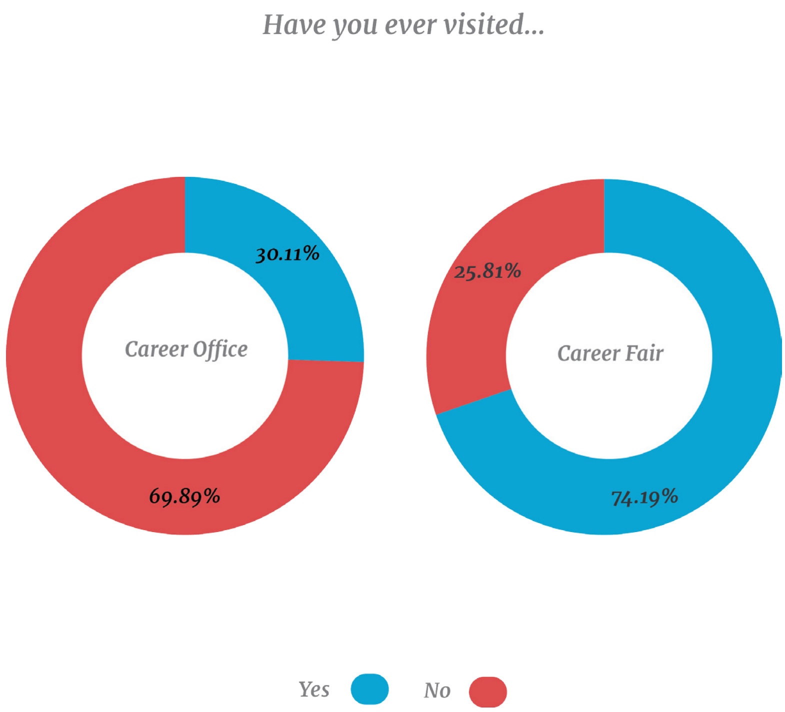


Fig 14.Visits to career fairs and career offices as percentage of all science students.

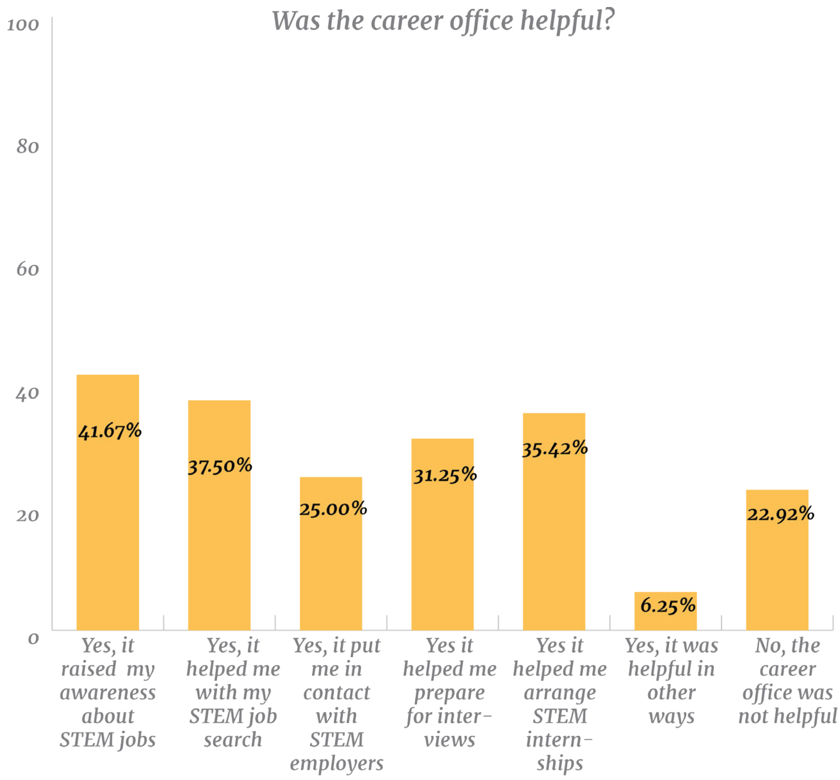


Fig 15. Perceptions of the helpfulness of career offices as a percentage of total STEM students.

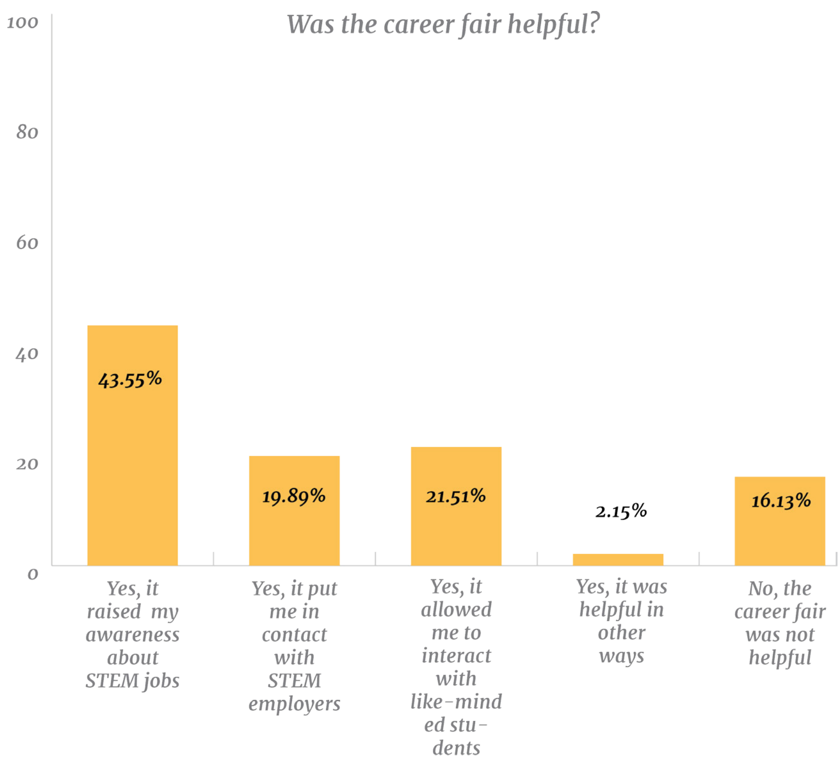


Fig 16. Perceptions of the helpfulness of career fairs as a percentage of total STEM students.

Correlation analysis indicated that there was no correlation between students' visits (whether they visited or not) to career fairs (r=0.23) and career offices (r=.88) and their intention to get a job in STEM after graduation. Again, this may be due to the fact that visits to these offices and fairs did not necessarily mean that students found them useful or significant to their job search processes or to their ability to interact with employers and likeminded students.

**INDUSTRY PERSPECTIVES**

*For most industry representatives, the most common way in which their companies recruit Emiratis is through career fairs. Some companies reported starting to do this abroad to recruit students who are studying in foreign countries. The other methods used were primarily sponsorship.*

*However, it is clear from our data that there is little alignment between industry intentions and student experiences. While industry participates in career fairs to introduce students to their business and to recruit them, only 20% of the students who were surveyed reported that career fairs allowed them to network with employers.*

## *Attitudes toward the STEM labor marked and confidence in preparedness for STEM*

By and large STEM students believed that jobs in the STEM labor market are of high quality (83%), and are highly available (85%). 88% were optimistic about finding jobs in that market. When asked if they felt prepared to enter the STEM job market, 89% reported that they did indeed feel prepared.

Correlation analysis showed that self-reported preparedness for the job market was not significantly correlated with student intention to continue on to STEM jobs (r=.153). However, attitudes toward the quality and availability of STEM jobs were significantly correlated with students' intentions to pursue STEM careers (r=.174).

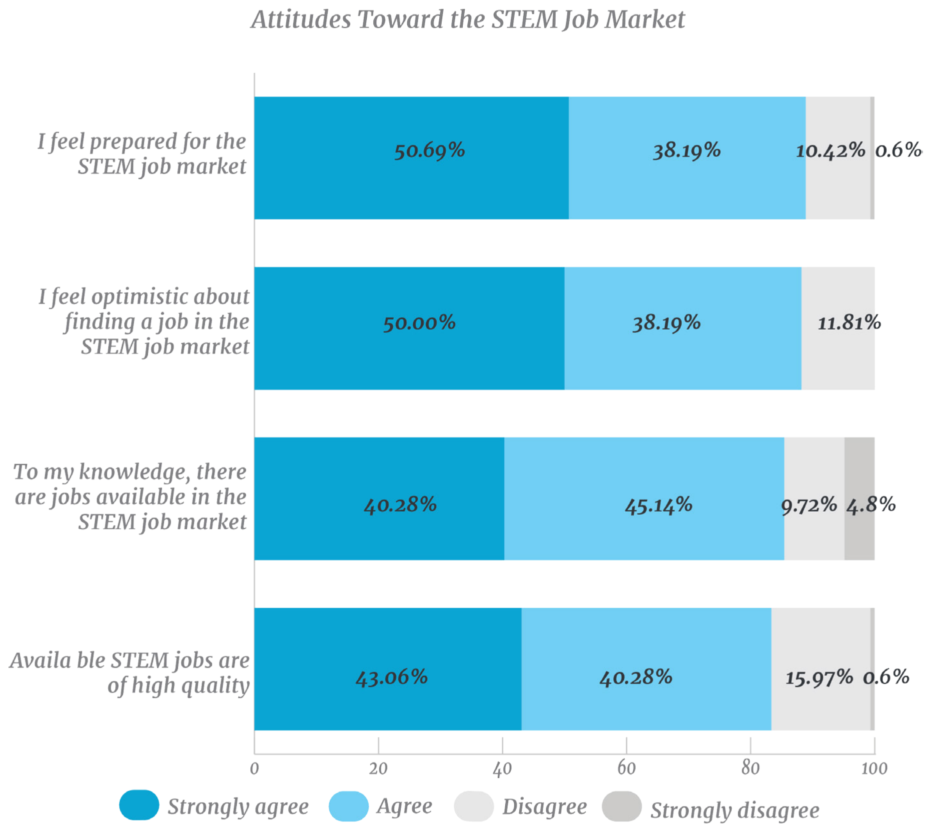


Fig 17. Attitudes toward the STEM job market and perception of preparedness for STEM jobs as a percentage of STEM students.

This is in conflict with accepted research that posits that confidence and competence are strong indicators of persistence in STEM. Focus groups participants indicated that, while students felt confident and prepared for careers in STEM, other factors become impediments to their desire to pursue careers in their fields of study. For example, one major issue that became apparent was the unsuitability of technical field work, particularly to the lives of women. Female STEM students felt that technical work in STEM fields exposes them to environments in which they would be the only woman present. Additionally, some female students recounted experiences in which they were participating in internships in the field and there were no female bathrooms. The perception of the time required to "do" STEM jobs, the undesirability of jobs in the private sector, and concerns over the lack of work/life balance in STEM jobs might impact students' intentions to pursue this kind of employment. In context, confidence and competence in STEM might become less influential factors.

**INDUSTRY PERSPECTIVES**

*High competition between employers to recruit students has led to students having a variety of attractive options. Recruiters noted that this means that packages for STEM students are becoming more and more inflated. As a result, young STEM professionals are able to choose the best possible option and end up "job hopping". Many spend no more than a year in each job. Additionally, students leave technical jobs because they are not as alluring as administrative or marketing jobs. Many qualified engineers opt to leave the field for more convenient work. The field, noted participants, was a special disincentive as it required long hours, work in remote areas, special uniforms, and a separation from the high standards of life that students have become accustomed to.*

*The two main obstacles facing recruiters, commented a focus group participant, were: "the competitive market, and high student expectations".*

*With regard to preparedness, recruiters indicated that students typically come to work with adequate theoretical training in STEM subjects. However, they lack practical skills. These skills, however, can be easily taught in the field. What was more important, according to our focus group, was commitment to the work and soft skills. Students, it was suggested, do not come with adequate soft skills.*

## *Student satisfaction with university education*

Students were asked to rate their satisfaction with their university STEM educations. They rated their satisfaction with their professors and instructors, facilities, course content, opportunities for internships and real world experience, extra-curricular activities, and the caliber of their peers.

88% of students were satisfied with their STEM professors and instructors, 85% were satisfied with their university facilities, 83% were satisfied with the content and curriculum of their STEM courses, 70% were satisfied with their real world STEM experience and 60% were satisfied with their extracurricular activities.

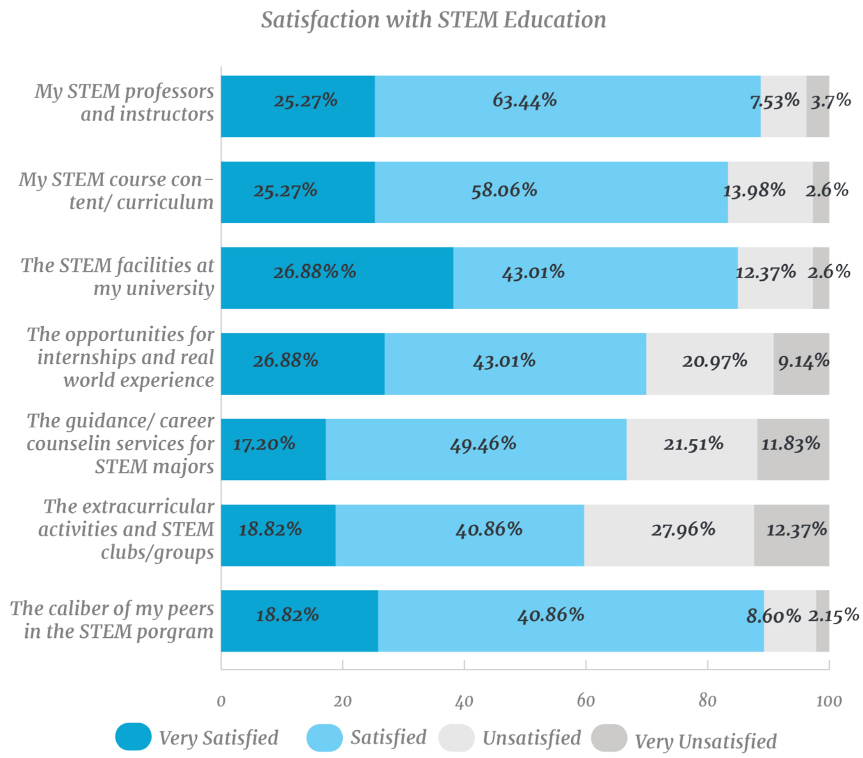


Fig 18. Satisfaction with STEM education as a percentage of STEM students.

Correlation analysis indicated that student satisfaction with their higher education was not significantly correlated with their intention to pursue a STEM career (r=0.11). However, there was a significant correlation between student satisfaction and attitudes toward the STEM labor market (r=.347). There was also a significant relationship between satisfaction in STEM education and students' perception of their own preparedness to enter the job market.

This indicates that while student satisfaction does not in and of itself correlate significantly with the intention to pursue STEM careers, it does influence, in a significant way, other factors that do have an impact on student intention to pursue STEM careers.

## *Gender differences*

There was a minor difference between the percentage of females that wanted to find STEM jobs (84%) and males who wanted to do so (71%). However, correlation analysis indicated that gender had a significant correlation to intention to pursue a career in STEM (r=-.181).

**INDUSTRY PERSPECTIVES**

*Recruiters acknowledged that the biggest pool of potential Emirati employees, today, consists of women. As such, they make a special effort to recruit women. However, the nature of field work has made it so that recruitment of women can be difficult. Travel to and from the field, the requirement to stay in the field for many days, and dress requirements leads to these jobs being perceived as unsuitable for Emirati women.*

*Industry is trying to address these issues by making the field more female friendly. Additionally, companies are trying to recruit women from the regions in which field sites are located. This will eliminate the need for travel and for lengthy stays in the field. Additionally, some are trying to make it so that female employees can do site related work from headquarters.*

## *Language fluency*

Correlation analysis indicated that there was no relationship between language proficiency and intention to pursue STEM careers (r=.002). However, focus group data indicated that while students who are enrolled or graduating may not have language related issues, students who enter STEM university programs face considerable challenges if their English language proficiency is poor. In fact, students claimed, university students are required to pass their TOEFL exams before they are allowed entry into any STEM (or major related) courses. Even while some students receive high school educations in English, that is not alone a sufficient indication that they have the necessary skills to succeed in English medium universities. All focus group participants told stories of friends or peers who dropped out because they were unable to persist in English medium courses or because they could not pass their English entry exams even after one or two years of trying.

## *Conclusions*

There is a variety of STEM university experiences among different STEM majors. Support for the sciences is not consistent among different fields. By and large, students who were the most satisfied and received the most support were students in engineering departments. Students in the life sciences and mathematics were the least satisfied and received the least support. Student satisfaction was significantly correlated with student attitudes toward the STEM job market and student attitudes toward the job market were significantly correlated with student intention to persist in the pipeline. As such, student satisfaction must be considered an important indicator. Furthermore, the discrepancy in institutional support across departments is reflected in Emirati students' choice of field. For example, engineering continues to attract the majority of STEM Emirati students, while physics, life sciences, and math attract the least.

Career support was also variable among departments. Engineering students were once again the most satisfied with their career guidance, while life sciences, and mathematics students were not as satisfied. Still, even while students generally reported being satisfied with career services, a very small percentage of them actually visited career offices. A much larger percentage visited career fairs, but only a small percentage of those reported that career fairs were helpful in meeting employers or finding jobs.

In addition to satisfaction and attitudes toward the job market, gender was found to be a significant factor impacting student intention to pursue STEM subjects. Gender was also important when discussing the context of STEM industries in the UAE. As the number of female STEM students increases, industries need to make STEM field work more female friendly and work to attract more Emirati women.

# Recommendations

## *Strengthening the STEM pipeline*

# UNIVERSITY STUDENT SURVEY FINDINGS

*How can we keep talented students in the pipeline?*

## *The role of government*

### 1 Providing special federal or local funds for STEM education

Special funds should be made available through scholarships and awards to students who display special interest and talent in STEM. These funds should be distributed, not on the basis of grades and class performance, but rather on special contests in which students are encouraged to invent, or innovate using STEM. This will increase the prestige of STEM, provide students with incentives to partake in STEM activities, give them an idea of how they can be used in interesting and exciting ways and reward them for their innovative ideas. This will fortify STEM identities among talented STEM students.

### 2 Cultivating communities of practice through youth organizations

Government should enable or create youth organizations that are focused on STEM activities. These groups should be dedicated to the practice of STEM, multidisciplinary interactions, collaborations, and group projects. This will cultivate communities of practice among young people, display government support for them, and enable identity formation.

### 3 Developing science curricula that enable identity development through dynamic activities, content and independent and group work

STEM curricula should focus on developing robust and adaptive skills sets. Students should be encouraged to think critically, experiment and understand STEM principles and ideas in context. STEM curricula should focus not only mastering math and science skills but also on interpretive and analytical skills.

## 4 Enabling science identities to emerge through special STEM awards and events

Special annual STEM awards and events should be organized around specialized STEM subjects – for example, mechanical engineering, robotics, software coding, chemical and biological innovations etc. This will encourage students of all ages to participate in STEM activities, but also to cultivate interest and identities in specific fields. These awards should emphasize group work and innovative ideas.

# *The role of schools*

## 1 Providing flexible and dynamic learning spaces for students to develop identities and interests in science

Schools should provide spaces and periods during the school day in which exploratory, experimental or immersive teaching methods can be utilized. Classrooms and labs should be organized in such a way that allows for collaborative work, immersion in subject matter and open dialogue and questioning of STEM subjects and principles.

## 2 Training teachers to be able to facilitate identity formation through innovative approaches

Schools should (1) train teachers so as to ensure that they have high competence in STEM subjects and (2) provide teachers with the space and the freedom to deliver STEM content in innovative ways. Teachers should be encouraged to deliver STEM content in a way that makes STEM relevant to student lives as well as identities.

## 3 Educating parents on the importance of encouragement of STEM aspirations

Schools should meet with parents and educate them on the importance of STEM subjects, their need in the labor market, and their utility for life. As such, parents should be encouraged to support students who display STEM leanings and interests through exposing them to extracurricular activities and STEM related media (books, magazines, movies etc.).

## 4 Schools should expose students to diverse STEM role models

Schools should make special efforts to expose students to STEM role models through the media, visitor lectures, and field visits. Schools can build collaborative relationships with both universities and industry to develop mentorship programs. Additionally, schools can set up shadow programs where students are encouraged to meet with and shadow STEM professionals. Special attention should be paid to ensuring that role models are diverse and representative of multiple segments of society.

## 5 Students should be provided with English language support prior to their arrival in university

Schools should set up intensive English language courses for students in their final year or two years of high school. This is to ensure that students are not hindered by their English language proficiency when they arrive at university. TOEFL and IELTS courses and support should be easily accessible for senior high school students.

# *The role of universities*

## 1 Universities should provide extra-curricular support for students to enable the development of communities of practice

Universities should pay special attention to providing and enabling the development of diverse extracurricular activities around STEM subjects. Funding, space, and resources should be provided to students to enable them to build communities of practice, meet regularly, and participate in STEM activities. As much as possible, institutions should try to encourage groups and activities from multiple STEM disciplines.

## 2 Funding should be provided for student projects to enable continued identity formation

Independent student projects should be encouraged in universities through providing funding and support for students who wish to formulate and implement project ideas outside of the classroom. Students should be encouraged to solve real life problems using STEM tools and innovations through the conditions and criteria for funding.

## 3 Career support and guidance

Career support and guidance should begin with effective, qualified, and committed student advisors. Advisors should be assigned to each student from the day they enter university. These individuals act as dedicated guides on what subjects to take, choosing a concentration, and navigating the university environment.

Career support for students should be improved to help students to (1) get STEM jobs, through interview support, CV support and access to networks of employers and (2) access internships and real world work experience before they graduate. Particularly, support for students in mathematics, physics and the life sciences needs to be improved. (3) Students should be given access to alumnae, professionals and mentors who are able to provide them with information on the experience of working in STEM.

# *The role of industry*

## 1 Industries should make their fields of work more female friendly

Companies and employers must make office, site and field cultures and spaces more female friendly. This can be done through educating employees on the importance of gender diversity in the workplace, making a special effort to hire more women, and providing resources and utilities for women.

## 2 Industries should build partnerships with universities to create communities of practice that include young STEM students

Industries should build partnerships with universities to enable the creation of communities of practice around STEM subjects. This can be done through shadowing programs, mentorship programs, youth activities, internships etc.

## 3 Industries should develop clear career plans and opportunities for development for young employees and new recruits

Companies that wish to attract students should develop clear and meaningful career plans for new recruits. Additionally, these companies must work on making these jobs fulfilling and ensuring that employees have a chance to partake in activities that help them to see the higher purpose of the organization and how it serves society. Continual development and a sense of service was important to young Emiratis who expressed interest in STEM fields, and so companies must cultivate these in order to retain young employees.

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