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## A Path Analysis of Student Interest in STEM, with Specific Reference to Qatari Students

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### ABSTRACT

This study sought to explore the factors that help predict students' interest in Science, Technology, Engineering and Mathematics (STEM) in Qatar. Drawing on recent work in the field, the present paper examines the intersection of personal characteristics (gender and grade level) and contextual (teacher) variables, and their association with interest in STEM. The study involved a nation-wide survey of preparatory and secondary levels of education in Qatar implemented in 2015, and data from a sample of 660 preparatory (middle) and secondary (high) school students. Factor analysis extracted five valid dimensions and a path analytic model suggested that student interest in STEM is influenced by teachers, perceptions of homework assignments, self-confidence and intention to pursue further study. Gender and level of education were also identified as variables likely to affect student interest in a STEM field. The paper concludes with important recommendations for policy and suggestions for further study and research.

**Keywords:** causal model, interest in STEM, Qatar National Vision 2030, path analysis

### INTRODUCTION

Science in its broadest sense is seen as a powerful means of understanding and solving the problems humanity is facing in the modern globalized world, including issues associated with climate change, health, immigration, natural resources, overpopulation, resource management, and so forth. It follows that STEM fields education is vital to our future and the future of the generations to come. With this being so, young people should be prepared to develop the skills and competencies needed to become the educators, innovators, researchers, and leaders in different STEM domains who can solve the most pressing problems facing humanity, now and in the future. However, a real challenge the modern world is currently confronted with is the dearth of people with the right STEM skill sets.

Without question, the need for qualified individuals will continue to grow rapidly in domains that require the necessary STEM knowledge and skills. Accordingly, a background and literacy in STEM have become essential

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#### **State of the literature**

- Personal interest is a major determinant of students' aspiration to and ultimately choice of a degree or occupation in a STEM field.
- Early interest in STEM influences future plans and eventual entry into a STEM field.
- Entering STEM majors in college for eventual employment in STEM fields is associated with both interest and proficiency in STEM.

#### **Contribution of this paper to the literature**

- Rather than making a contribution to the relevant theorization regarding interest in STEM, the focus of this study is to understand influences that bear upon students' interest in a STEM degree or profession.
- Because little is known about students' interest in and aspiration to a degree or career in STEM fields in Qatar and the Arab region by extension, this study tries to identify the factors likely to influence young Qataris' interest in STEM.
- The findings of this study can enhance our understanding of students' interest in STEM in a non-Western context.

for access to well-paid, high-status jobs (Greenwood et al., 2011). However, the disproportionate influence of STEM raises concerns that not enough STEM workers are being produced who can compete successfully in a global economy, while at the same time science educators in countries around the world struggle with keeping students active and interested in STEM (Boe et al., 2011; Mahoney, 2010; Gasiewski et al., 2012).

Referred to as STEM fields (science, technology, engineering, and mathematics) (Fouad et al., 2010; Goldman & Penner, 2014; Ing & Nylund-Gibson, 2013), policymakers and researchers have identified and grouped occupations they believe are key to global competitiveness and central to modern society. Concerns about shortages of qualified workers are especially salient in Qatar where a sharp deficit of STEM field skills is especially high (Jiwaji, 2014; Osman & Anouze, 2014). The system of education is often blamed for not being able to prepare citizens for the job market (Brewer et al., 2007; Gonzalez et al., 2008).

Many studies about children's interest in STEM degrees or professions have been conducted in North America and Western Europe (see for example Crisp, Nora & Taggart, 2009; Hilton & Lee, 1988). Yet, there are few places in the world with more need for STEM professionals than Qatar, a country that has abundant resources in oil and natural gas but a small citizen population with an even smaller subset trained in the occupations needed for sustaining the oil and gas industry. There is, therefore, a great need for a shift in strategy to redress the situation and counterbalance such paucity of skills required in STEM domains (Ministry of Development Planning and Statistics, 2015).

This study is both timely and needed to contribute to the efforts investigating the role that the school system as a whole can play in promoting and improving the quality of STEM education. The inspiration for our interest in this topic emanated from the realization that despite the great efforts exerted and the massive resources allocated by Qatar's leaders in an ongoing attempt to improve the quality of education, not enough attention has been paid to the ways and means of promoting the study of STEM. National reports underline the issue of Qataris having very low enrollments in programs that are "central to Qatar's economic development including science, mathematics and technology" (GSDP, 2012, p. 2). In the context of increasing concern regarding the shortage of citizens who have the critical skills and competencies needed for the knowledge economy, this study is timely and needed to investigate young Qataris' interest in STEM subjects.

Whereas expectations for Qatari students to perform at higher levels in STEM subject areas are very high, they are still lagging behind in international test scores on mathematics and science. Their performance in the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) – two major large-scale international assessments used to evaluate student performance in mathematics and science – is especially low. Results from TIMSS in 2007, 2011 and 2015 revealed poor test scores

achieved by Qatar's students (Bouhlila, 2011; Mullis et al., 2009; Mullis et al., 2016) and similar findings were concluded from PISA in 2006, 2009, 2012, and 2015 (Baldi et al., 2007; OECD, 2010, 2014, 2016).

If Qatar's system of education is to prepare a generation that is capable of meeting the demands of modern society and the highly competitive employment market, it is vital to focus more closely on developing the necessary STEM knowledge, skills and competencies. This is particularly so since the intent of the country's officials is to get young Qataris to be interested in STEM fields early in hopes of filling a future workforce void.

## BACKGROUND

The State of Qatar has taken wide strides to develop its society into a regional hub of education and modernize its entire education system (GSDP, 2012). In 1998, discontent with the state of education in Qatar, the leadership commissioned the RAND corporation to assess the country's K-12 education system and design reform plans to enable it to be on a par with world-class standards and meet the evolving needs of Qatar (Brewer et al., 2007). In the *Qatar National Vision 2030* (GSDP, 2008), the State of Qatar detailed goals to move from a reliance on its hydrocarbon resources to a knowledge based economy by the year 2030; at the heart of these plans are the STEM fields.

Many studies highlight the marked lack of trained Qatari citizens in critical STEM fields (Abdulwahed et al., 2013; GSDP 2011; Shediak & Samman, 2010; Weber, 2014a, 2014b). At present, the demographic composition in Qatar demonstrates the country relies heavily on expatriate labor force with a very high national-foreign ratio (Berrebi et al., 2009; Ibnouf et al, 2014). The government of Qatar, as many places in neighboring Arab Gulf states, has responded to shortages in STEM fields by importing highly skilled workers from Europe, North America, South East Asia, and elsewhere. At the same time, educational reforms have resulted in greater emphasis on STEM education and training as fundamental assets for Qatar's future knowledge society (Barnett, 2015; Oxford Strategic Consulting, 2015, 2016; Wiseman et al., 2014).

The discrepancy between the skills graduates possess and the rising demand for skills in the labor market throughout the GCC countries (Shediak & Samman, 2010) suggests that the private sector in particular has had to rely on foreign workers for STEM occupations (De Bel-Air, 2014). For instance, as is pointed out by Berrebi, Martorell and Tanner (2009, p. 1), "the demand level for skilled and unskilled labor far outstrips that which Qatari nationals can provide." For many, not enough of Qatar's youth have access to quality STEM learning opportunities and too few students see STEM disciplines as springboards for their future careers (Rugh, 2002; Said, 2016, Said et al., 2016; Weber, 2014a, 2014b).

A significant contribution this study has for the existing body of scholarly knowledge consists in the relevance of its findings for educators and stakeholders in Qatar. Furthermore, the results concluded from it may inform educational policy in the country at a time when decision makers call for promoting STEM literacy that is much needed for Qatar in an increasingly science- and technology-driven world. Indeed, training and preparing literate citizens in various STEM disciplines has been a prime focus in the reform plans of many countries. Despite the substantial progress witnessed in most aspects of education infrastructure in Qatar, there is still a great need for improving STEM education as well as tackling the underachievement of students in STEM subjects at all levels of schooling.

The study can also be useful in contemplating how to increase the number of students who pursue degrees and careers in STEM fields. By examining factors that shape student interest in STEM fields, the study can provide insights into how to cultivate the skills and competencies necessary for effective STEM engagement in the post-compulsory years of schooling, and ultimately ensure students are well-prepared and suitably qualified to engage in STEM professions. Focusing on the school system is of crucial significance given the vital role that education plays in preparing citizens for the job market. More than ever before, the importance of STEM education is of central value in today's changing world.

## LITERATURE REVIEW

Increasing global concern regarding the dearth of people who possess the critical skills and competencies needed for a sustainable knowledge economy has led to a feverish competition for finding the right people with the right skills in many countries worldwide. The hunt for talent has now taken immense dimensions (Beechler & Woodward, 2009; Carter, 2011; Michaels et al., 2001). In the United States, for example, ensuring sufficient numbers of graduates with the right skills in science, technology, engineering, and mathematics occupations has become a top priority for the nation (Chen & Soldner, 2013). Global concern regarding the paucity of people who possess the critical skills and competencies needed for a sustainable knowledge economy has led to a feverish competition for finding the right people with the right skills in many countries worldwide. The hunt for talent has now taken immense dimensions (Beechler & Woodward, 2009; Carter, 2011; Michaels et al., 2001) and gaps in STEM skills pipeline, especially at the secondary school and university levels, confirm the need to pique and nurture students' declining interest in STEM disciplines.

While research efforts in recent decades have helped broaden our understanding of what influences children's interest in STEM fields in Western contexts, it appears that published research that focuses on STEM and the factors that spark children's interest in STEM degrees or professions in Qatar is clearly lacking. Using survey-based quantitative data, this study sought to fill this gap and tap an area that remains of paramount importance to the future of the country and its sustainable development. This it did by providing an Arab, Middle Eastern perspective on students' interest in and aspirations for STEM degrees and careers.

Research on the factors that help predict children's interest in pursuing STEM subjects in secondary and tertiary education has largely focused on examining separate variables, including involving personal characteristics (academic achievement, motivation, self-esteem), social factors (parental influences, socio-economic status) and the future educational and career plans of young adolescents. This study looks at four different variables grouped together: impact of the teacher, perceptions of homework assignments, self-confidence and intention to pursue further study. With these variables brought together, the paper provides an informed perspective on the factors that shape Qatari students' interest in STEM degrees and professions. In particular, not enough is known about how students' perceptions of homework assignments impact their interest in STEM fields.

The literature on students' interest in STEM provides insights into factors that may be relevant to Qatar particularly since very little is known about young students' interest in STEM in the context of Qatar. The sections below provide a general overview of some of these factors, namely interest, self-confidence, the teacher, homework assignments, and intention to pursue further study.

### **Interest in STEM**

Many studies have identified personal interest as a key factor in students' aspiration to and ultimately choice of a STEM degree or occupation (Beggs et al., 2008; Hall et al., 2011; Kuechler et al., 2009). Although an agreed on theoretical orientation towards the concept of interest does not exist (Renninger & Hidi, 2011), there is general consensus on the key aspects and characteristics of the concept of interest (Hasni & Potvin, 2015; Krapp & Prenzel, 2011). A substantial body of research confirms that the construct of interest has been used in various fields of study and research, such as education, psychology, sociology, etc. (Krapp & Prenzel, 2011). The present study mainly explores STEM situated within the domain of education (Hasni & Potvin, 2015).

The literature stresses the multidimensional definition of the interest concept that encompasses emotional, cognitive and other attributes (Hidi & Renninger 2006; Hidi et al., 2004; Schiefele, 2009). According to Krapp (2007) the construct of interest is "conceptualized as a relational concept: an interest represents or describes a more or less enduring specific relationship between a person and an object" (p. 8). Personal characteristics such as gender, grade level, country of origin, etc. are strongly associated with interest (Potvin & Hasni, 2014). Similarly, school-related variables (e.g. the teacher and teaching methods) and sociological factors (e.g. home background and parents' socioeconomic characteristics) are important predictors of interest (Hasni & Potvin, 2015; Krapp & Prenzel, 2011).

Recent research postulates that interest in STEM greatly influences student involvement in relevant science disciplines (Ainley et al., 2005; Ainley, 2012) and thus affects their aspiration to future careers associated with these fields of study (Baram-Tsabari & Yarden, 2009; Hasni & Potvin, 2015). To increase the number of individuals entering STEM majors in college for eventual employment in STEM fields, students must be both proficient and interested in STEM (BHEF, 2010). Research indicates that children's early interest in STEM is an indicator of the likelihood they would complete degrees in STEM (Becker & Park, 2011; Hayden et al., 2011; National Research Council, 2011). Using data from the National Education Longitudinal Study of 1988, Tai et al., (2006) found that roughly half of 8<sup>th</sup> graders in the study followed through with their plans and eventually achieved a degree in a STEM field, while far fewer students with non-STEM aspirations eventually switched into a STEM field.

### **Student Self-Confidence**

Available research has shown that self-confidence in one's ability is associated with interest and achievement in STEM subjects (Ganley & Lubinski, 2016; Heaverlo, 2011). Used interchangeably with the concept of self-efficacy, self-confidence is a psychological construct used to measure an individual's belief in their own abilities and personal worth to execute a course of action, accomplish a specific goal or task such as studying, and bring about an outcome (Bandura, 1977; Bénabou & Tirole, 2002; Bong & Clark, 1999; Lee & Stankov, 2013; Morony, et al., 2013). This entails trust in oneself, believing in one's aptitude and capabilities (Bandura, 1997; Bong & Skaalvik, 2003). This study deals with self-confidence in isolation from the construct of self-efficacy.

Looking at the relationship between self-confidence and gender, Rittmayer & Beier (2008) report a gender gap pointing to differences in boys' and girls' beliefs in their math and science abilities. In their view, this gap is partly responsible for the shortage of women in science, technology, engineering, and mathematics (STEM) classes and careers (e.g., Eccles, 1994, p.1). Similarly, Sarsons and Xu (2015) contend that females display less of confident levels than males from a young age, which they say plays a key role in explaining differences in their academic success and career choices. Self-confidence has been shown to influence academic achievement and success (Bénabou & Tirole, 2002; Rittmayer & Beier, 2008; Tavani & Losh, 2003). According to Hill and colleagues (2010), for example, students who do not possess confidence in their math or science abilities are less likely to participate in fields that require those abilities and will give up in the face of difficulties, and females are specifically vulnerable in losing confidence in STEM fields.

### **Impact of the Teacher**

The literature on STEM education stresses the impact of teachers on student interest in STEM fields (Cleveland et al., 2017; Griffith, 2010; Hill et al., 2005; Price, 2010; Watkins & Mazur, 2013). In their review of research involving student attitudes toward science, Osborne and colleagues (2003) concluded that science teachers play an important role in contributing to the prediction of student interest in science. According to Maltese and Tai (2010, p. 683), "teachers may be influential in turning students onto and also off from science." The role of teachers in promoting student love of science (Taylor et al., 2008) as well as their questioning, scientific inquiry, discovery and problem-solving cannot be underestimated (Dennen et al., 2007; Gormally et al., 2009; Marshall et al., 2009). Studies by Bettinger and Long (2005) indicated that instructors serve as role models and reported a positive association between instructors and students' course selection and choice of major.

Research has also shown that teachers greatly influence their students' educational achievement in STEM subjects (Blazar, 2016; Freeman et al., 2014; Sadler et al., 2013; Thompson, 2001). One of the reasons reported to lie behind poor student performance at school, especially regarding STEM subjects, is the inability of schools to sufficiently staff classrooms with qualified teachers, and this is mainly due to a shortage in STEM teachers (Ingersoll, et al., 2014). A report prepared by the Sutton Trust (2011) reveals that improving the quality of teachers can have a major impact on school performance, for teachers are the most significant element in schools that policy makers can focus on to enhance students' achievement. For example, with an effective math teacher, students can gain 40% more in their learning compared to a less effective one, and having an effective teacher improves the student achievement by a third at a GCSE grade (The Sutton Trust, 2011).

### **Perceptions of Homework Assignments**

Homework assignments are an essential part of students' learning experience as recent research confirms. Many studies show that homework has a profound impact on learning outcomes as it aids in enhancing academic performance and achievement (Kitsantas & Zimmerman, 2009; Tyson et al., 2007; Zimmerman & Kitsantas, 2005). An added advantage of homework assignments is that they are positively associated with student achievement at school, as in the view of Trautwein (2007) and Trautwein and Köller (2003). Moreover, the literature reveals that homework provides possible remedies for different educational deficits students confront at school (Shapiro, 1996; Trautwein et al., 2002).

In general, the value of homework assignments lies in that they serve to attain different goals. More specifically, as Smolira (2008) argues, homework is useful in encouraging student learning, increasing their understanding of the material and enhancing their attention in class. Assigning schoolwork to students does not simply improve student academic achievement; it also helps to develop skills related to their responsibility, learning autonomy, and time management (Eaton et al., 2014; Warton, 2001), especially when students actively engage in assigned tasks (Cates & Skinner, 2000).

### **Intention to Pursue Further Study**

In this study, the concept of intention is used to mean a person's intent, desire or aspiration to pursue post-secondary education (Anderson & Bourke, 2000). As is clear from the literature, students' intention to go after their educational aspirations depends on many factors, including personal, social and cultural influences (McDonough, 2004; Rock, 2010). An individual's personal characteristics, such as self-esteem, motivation, achievement and personal satisfaction, are closely associated with their intention to engage in further study (Anderson & Bourke, 2000). Additionally, there is a relationship between social factors, including family influences (finance and economic status, parental support), and student intention to continue post-secondary education (Bloom, 2007; Chen & Zimitat, 2006; Louie, 2007; Pimpa, 2003; St. John, 2002). Recommendations from family members, peers and friends have also been cited as important "push" factors that motivate student choice of future study (Mazzarol & Soutar (2002).

Other factors that influence one's intention to engage in further education include the worth that students place on education and the value they attach to it, as studies by Anderson & Bourke (2000) point to. More specifically, school-related factors such as school reputation, school climate, course availability have been found to shape young adolescents' plans to continue post-secondary studies (Forbes & Skamp, 2014; Price et al., 2003; Sjaastad, 2012). For example, McDonough (2004) attributes high school student transition to college to factors associated with the quality of the curriculum, college culture, especially regarding academic standards and communication related to college choice and transition, and the role of staff members in advising and counseling students as they prepare for transitioning to higher education.

### **RESEARCH PROBLEM/QUESTIONS**

Lack of nationals armed with the skills and talents that are critical for the country's development and prosperity in a rapidly changing world is a real concern in Qatar (Jiwaji, 2014; Osman & Anouze, 2014) as the country braces to transition into a knowledge society, as outlined in the *QNV 2030* (GSDP, 2008). Central to this strategic goal is STEM education. The aim of this study was to identify the factors that influence preparatory and secondary Qatari students' interest in a degree or profession in a STEM field. For purposes of the study and drawing on previous research, we sought to decipher the relationship of the following four constructs to Qatari students' interest in STEM:

- a) Impact of the teacher,
- b) Perceptions of homework assignments,

- c) Self-confidence, and
- d) Intention to pursue further study.

As we tried to examine what motivates students to indicate interest in STEM, our aim was to see if there are any significant relationships between the participants' gender and level of education, and the variables discussed above. In carrying out this research, answers were solicited to the following questions:

- 1) What factors influence students' interest in STEM fields of study or work?
- 2) Are there any significant differences in students' responses with respect to their gender?
- 3) Are there any significant differences in students' responses with respect to their grade level?

We expect there to be significant relationships among students' personal characteristics (gender and grade level) and interest in STEM. The available literature on student interest in STEM subjects in general provides insights into the influences that may be relevant to the context of Qatar particularly since very little is known about this topic in this country and the neighboring states.

## METHODOLOGY

### Participants

For purposes of this study, which used a randomly stratified sample, we focused on data from the Qatari national students (n=660) in preparatory and secondary schools representing 38 independent and other schools in Qatar. Overall, the study involved 380 preparatory students (184 in grade 8 and 196 in grade 9) and an additional 280 secondary students (136 in grade 8 and 144 in grade 12). Students' average age is 13 for grade eight, 14 for grade nine, 16 for grade eleven, and 17 for grade twelve. Regarding gender, 57% of the student sample are female and 43% males. A weighting variable was created to take into account the selection probability and non-responses. With the above number of completions, the sampling error was calculated to be +/- 2 percentage points.

There are four predominant school types in Qatar that have emerged partially in response to the cleavage between citizens and immigrants but also because of a series of education reforms initiated in 2002 (GSDP, 2011; Stasz et al., 2007). These are: Independent (public) schools, international private schools, Arabic private schools and community schools that follow the curricula of particular countries.

### Procedure

The data used in this study was gathered from students who participated in the 2015 Qatar Education Study (QES 2015) using survey questionnaires. The QES involved a nationally representative two-stage probability sample of Qatari students in grades 8 and 9 (preparatory schools) and grades 11 and 12 (secondary schools). The sampling frame for the QES 2015 was developed by SESRI using a comprehensive list of all public schools in Qatar supplied by the Ministry of Education and Higher Education. In Stage One, proportionate school sampling was used based on school type, school size, gender, and grade level. Stage Two involved random selection of one class from each school grade with all students in that class included in the study.

Forty-two schools were sampled for this study, with four schools refusing to participate. Classrooms were randomly chosen in 38 schools and all students in selected classrooms participated in the survey. The main challenge faced in using stratified random sampling for this study is associated with the time needed to go through the lengthy retrieval process prior to receiving the full list of the entire student population in the country from the Ministry of Education and Higher Education in Qatar.

This descriptive study utilized survey research conducted by the Social and Economic Survey Research Institute (SESRI) at Qatar University. Self-administered paper-and-pencil questionnaires were utilized to collect the data needed for this study. The questionnaires were distributed in class and highly trained SESRI researchers were

**Table 1.** KMO and Bartlett's Test

<b>Kaiser-Meyer-Olkin Measure of Sampling Adequacy</b>		.740
<b>Bartlett's Test of Sphericity</b>	Approx. Chi-Square	2296.050
	Df	120
	Sig.	.000

present in the classroom to oversee the process of questionnaire administration. Following approval from Qatar University's Internal Review Board, official letters requesting permission to implement the study were submitted to the relevant schools. Students and parents were informed about the goal of the research and were assured their responses would be strictly confidential; they were also told participation in the survey was voluntary. The questionnaires were administered after consent for the study was received.

### Measures

Gender and grade level were used as control factors (test conditions) to check if there are any significant differences in student responses relative to interest in STEM.

*Gender.* This was used as a dichotomous variable (female=1, male=0). The gender distribution of respondents was almost even between female (49%) and male (51%).

*Grade Level* was obtained from the original list provided by the Ministry of Education and Higher Education (previously the Supreme Education Council). 8<sup>th</sup> and 9<sup>th</sup> grades were collapsed into preparatory school and 11<sup>th</sup> and 12<sup>th</sup> grades into secondary school. As is the case with gender, the distribution of students was divided nearly equally between preparatory (49%) and secondary (51%).

### Establishing the Construct Validity and Reliability of the Instrument

The data were tested with regard to the appropriateness for component analysis, using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. KMO tests whether the data is sufficiently adequate and highly variable in order to conduct component analysis. The KMO should be greater than 0.5 for a satisfactory factor analysis to proceed. The KMO values range from 0 to 1, with values closer to 1 indicating high variability in the data. As such, values between 0.7 and 0.8 are good (Hutcheson & Sofroniou, 1999), which confirms that factor analysis is appropriate for our data.

The questionnaire designed for this research is composed of 69 dichotomous, open ended and closed scale items. Of these, 16 scaled items were measured using Likert scale in factor analysis. Two statistical tests were conducted in order to determine the suitability of factor analysis. First, the Kaisers-Meyer-Olkin (KMO) measure of sampling adequacy score of 0.740 was well above the recommended adequacy level of 0.50. Second, the Bartless test of sphericity was significant (Chi Square = 2296.050, P= 0.000), indicating that there are adequate inter-correlations between the 16 items which allow the use of factor analysis. Principal axis factoring was employed as an extraction method with oblique rotation method.

## RESULTS & DISCUSSION

Five factors were extracted using the Eigen value greater than one criterion. The five-factor solution accounted for 62.163 per cent of the total variance. The five factors were easy to label (see **Tables 1, 2, and 3**).

Factor Analysis extracted five valid dimensions identified as reliable using Cronbach alpha, as is shown in **Table 2**.



**Table 2.** Total Variance Explained

Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings <sup>a</sup>
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.332	27.073	27.073	4.332	27.073	27.073	3.044
2	1.996	12.472	39.545	1.996	12.472	39.545	1.844
3	1.352	8.450	47.995	1.352	8.450	47.995	3.346
4	1.220	7.627	55.622	1.220	7.627	55.622	2.476
5	1.047	6.542	62.163	1.047	6.542	62.163	1.610
6	.956	5.974	68.138				
7	.900	5.626	73.764				
8	.811	5.070	78.833				
9	.649	4.053	82.887				
10	.557	3.483	86.369				
11	.543	3.391	89.760				
12	.404	2.528	92.288				
13	.375	2.344	94.632				
14	.304	1.902	96.534				
15	.290	1.812	98.346				
16	.265	1.654	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

**Table 3.** Structure Matrix

	Component				
	1	2	3	4	5
Mathematics will be useful for my future	<b>.779</b>	-.056	-.342	-.211	.272
Science will be useful for my future	<b>.732</b>	.049	-.237	-.301	.038
I usually look forward to Science classes	<b>.722</b>	.083	-.348	-.321	-.088
I usually look forward to Mathematics classes	<b>.702</b>	.063	-.397	-.118	.145
I am often afraid of asking questions in Science classes	.004	<b>.881</b>	.036	.117	-.183
I am often afraid of asking questions in Mathematics classes	.004	<b>.865</b>	.139	.155	-.251
Teachers care about students	.379	-.048	<b>-.828</b>	-.276	.113
Teaching is good	.333	-.072	<b>-.778</b>	-.274	.172
Most of my teachers really listen to what I'm trying to say	.267	-.085	<b>-.777</b>	-.213	.090
When I work hard on schoolwork, my teachers praise my effort	.355	.028	<b>-.776</b>	-.235	.096
How would you rate the level of difficulty of homework assignments in science?	.140	-.243	-.220	<b>-.759</b>	-.064
How helpful do you find the assignments (science)?	.404	.192	-.322	<b>-.706</b>	.205
How helpful do you find the assignments (math)?	.451	.087	-.312	<b>-.689</b>	.335
How would you rate the level of difficulty of homework assignments math?	.188	-.328	-.307	<b>-.597</b>	.011
How likely is that you would go to college education after you leave secondary/high school?	.091	-.137	-.113	.013	<b>.793</b>
To what extent are you confident that you will graduate from secondary/high school?	.079	-.241	-.145	-.168	<b>.750</b>

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalization.

**Table 4.** Cronbach Alpha (reliability test)

		Mean	St. Deviation	N	Cronbach's Alpha
<b>Interest in STEM</b>	Mathematics will be useful for my future	1.70	.974	613	.726
	I usually look forward to Science classes	1.71	.940	613	
	Science will be useful for my future	1.62	.960	613	
	I usually look forward to Mathematics classes	1.85	.943	613	
<b>Student self - confidence</b>	I am often afraid of asking questions in Science classes	3.10	1.059	623	.792
	I am often afraid of asking questions in Mathematics classes	3.04	1.050	623	
<b>Impact of the teacher</b>	Most of my teachers really listen to what I'm trying to say	1.93	.890	617	.821
	When I work hard on schoolwork, my teachers praise my effort	1.73	.835	617	
	Teachers care about students	1.82	.820	617	
	Teaching is good	1.79	.804	617	
<b>Perception of homework assignments</b>	How would you rate the level of difficulty of homework assignments in mathematics?	2.16	.808	570	.677
	How would you rate the level of difficulty of homework assignments in science?	2.15	.763	570	
	How helpful do you find the mathematics assignments?	1.67	.861	570	
	How helpful do you find the science assignments?	1.66	.842	570	
<b>Intention to pursue further study</b>	How likely is that you would go to college education after you leave secondary/high school?	1.33	.610	590	.506
	To what extent are you confident that you will graduate from secondary/high school?	1.38	.607	590	

- Factor one was labelled “interest in STEM” and is highly reliable, as shown by Cronbach’s alpha of 0.726;
- Factor two was labelled “student self-confidence” and is highly reliable, as shown by Cronbach’s alpha of 0.792;
- Factor three was labelled “impact of the teacher” and is highly reliable, as shown by Cronbach’s alpha of 0.821;
- Factor four was labelled “perception of homework assignments” and is highly reliable, as shown by Cronbach’s alpha of 0.677; and
- Factor five was labelled “intention to pursue further study” and is highly reliable, as shown by Cronbach’s alpha of 0.506.

### Testing the Relative Importance of the Independent Variables to the Explained Variation in the Dependent Variable

The questionnaire used in this study has five valid dimensions that are reliable. In regressing the dependent variable interest in STEM on the other four dimensions (i.e. the independent variables), the results indicate that interest in STEM is determined by student self-confidence at 0.001 level of significance, impact of the teacher at 0.000 level of significance, perception of assignments at 0.000 level of significance and intention to pursue further study at 0.027 level of significance (see [Tables 5, 6, 7 and 8](#) below).

**Table 5.** Correlations

	Interest in STEM	Student self-confidence	Impact of the teacher	Perception of homework assignments	Intention to pursue further study
<b>Pearson Correlation</b>					
Interest in STEM	1.000	.077	-.408	-.305	.139
Student self-confidence	.077	1.000	.065	.109	-.127
Impact of the teacher	-.408	.065	1.000	.304	-.142
Perception of homework assignments	-.305	.109	.304	1.000	-.075
Intention to pursue further study	.139	-.127	-.142	-.075	1.000
<b>Sig. (1-tailed)</b>					
Interest in STEM	.	.047	.000	.000	.001
Student self- confidence	.047	.	.078	.009	.003
Impact of the teacher	.000	.078	.	.000	.001
Perception of homework assignments	.000	.009	.000	.	.052
Intention to pursue further study	.001	.003	.001	.052	.
<b>N</b>					
Interest in STEM	473	473	473	473	473
Student self- confidence	473	473	473	473	473
Impact of the teacher	473	473	473	473	473
Perception of homework assignments	473	473	473	473	473
Intention to pursue further study	473	473	473	473	473

**Table 6.** Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.475 <sup>a</sup>	.226	.219	.88362333

a. Predictors: (Constant), Intention to Pursue Further Study, Perception of homework assignments, student self- confidence, impact of the teacher

**Table 7.** ANOVA<sup>a</sup>

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	106.590	4	26.648	34.129	.000 <sup>b</sup>
	Residual	365.410	468	.781		
	Total	472.000	472			

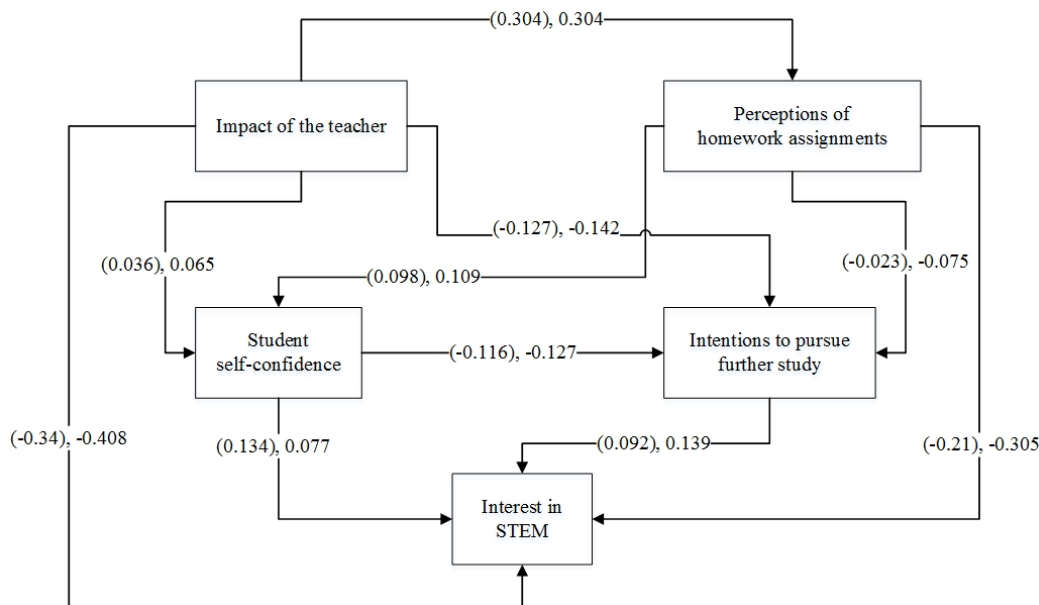
a. Dependent Variable: Interest in STEM

b. Predictors: (Constant), Intention to pursue further study, perception of homework assignments, student self-confidence, impact of the teacher

**Table 8.** Coefficients<sup>a</sup>

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.071E-16	.041		.000	1.000
Student self-confidence	.134	.041	.134	3.246	.001
Impact of the teacher	-.340	.043	-.340	-7.901	.000
Perception of homework assignments	-.210	.043	-.210	-4.886	.000
Intention to pursue further Study	.092	.041	.092	2.224	.027

a. Dependent Variable: Interest in STEM



**Figure 1.** STEM predictors pathway analysis chart

### Path Analysis: Calculation of Path Coefficients

Path analysis, as an extension of multiple regression, was employed to estimate the significance of the hypothesized causal connections between the variables chosen for this study (Land, 1969). Since our study is based on correlations, the prediction equation for interest in STEM in standardized scores is:

$$Z_y = \beta_1 Z_{x1} - \beta_2 Z_{x2} - \beta_3 Z_{x3} + \beta_4 Z_{x4}$$

$$Z_y = .134 Z_{x1} - .340 Z_{x2} - .210 Z_{x3} + .092 Z_{x4}$$

Based on logical basis, the researchers constructed the causal model shown in **Figure 1**. The correlation between parentheses is the magnitude of the true and direct effect between every two variables (known as path coefficients). As such, the correlation between the other values on each arrow, not in parentheses, represents the total effect (direct effect plus indirect effects). The casual model shows that the direct effect between student self-confidence and interest in STEM decreases because of the other intervening variables while the direct effect of each of the three predictors increases due to the effect of the other intervening variables.

**Table 9.** Coefficients (male)<sup>a</sup>

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-.086	.069		-1.243	.216
Student self-confidence	.176	.060	.199	2.962	.004
1 Impact of the teacher	-.356	.064	-.388	-5.592	.000
Perceptions of assignments	-.173	.066	-.181	-2.637	.009
Intention to pursue further study	.098	.064	.104	1.535	.127

a. Dependent Variable: Interest in STEM

**Table 10.** Coefficients (female)<sup>a</sup>

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.069	.052		1.324	.186
Student self-confidence	.072	.058	.065	1.245	.214
1 Impact of the teacher	-.305	.059	-.289	-5.167	.000
Perceptions of assignments	-.254	.057	-.247	-4.428	.000
Intention to pursue further study	.088	.054	.085	1.609	.109

a. Dependent Variable: Interest in STEM

The mathematical model below shows that the intervening variables (impact of the teacher, perception of homework assignments, and intention to pursue further study) led to a decrease in the direct effect between students' self-confidence and interest in STEM.

$$r_{53} = \frac{\sum Z_3 Z_5}{N} = \frac{1}{N} \sum Z_3 (Z_5)$$

$$r_{53} = \frac{1}{N} \sum Z_3 (P_{51}Z_1 + P_{52}Z_2 + P_{53}Z_3 + P_{45}Z_4)$$

$$r_{53} = P_{51}r_{13} + P_{52}r_{32} + P_{53} + P_{54}r_{34}$$

$$r_{53} = (-0.34)(0.065) + (-0.210)(0.109) + (0.134) + (0.139)(-0.127)$$

### Introducing Gender and Grade Level as Test Factors (i.e. Conditions)

#### 1. Gender as a predictor of interest in STEM

The results show that if gender is taken as a control factor and the analysis is repeated only for Qatari male students, intention to pursue further study is ruled out and interest in STEM is significantly predicted by impact of the teacher (0.000), student self-confidence (0.004) and perceptions of homework assignments (0.009) (Table 9).

Additionally, as Table 10 demonstrates, if gender is used as a control factor and the analysis is repeated only for female Qatari students, then interest in STEM is significantly determined by two variables only, namely impact of the teacher (0.000) and perceptions of homework assignments (0.000).

#### 2. Grade level as a predictor of interest in STEM

The results also indicate that if grade is used as a control factor and the analysis is repeated only for Qatari preparatory school students (grades 8 and 9), the results are highly significant. As Table 11 shows, interest in STEM is significantly determined by the four variables of student self-confidence (0.009), impact of the teacher (0.000), perceptions of homework assignments (0.000) and intention to pursue further study (0.019).

**Table 11.** Coefficients (grades 8 & 9)<sup>a</sup>

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.001	.054		.020	.984
Student self-confidence	.136	.052	.143	2.621	.009
1 Impact of the teacher	-.297	.056	-.302	-5.327	.000
Perceptions of assignments	-.217	.055	-.222	-3.921	.000
Intention to pursue further study	.129	.055	.129	2.362	.019

a. Dependent Variable: Interest in STEM

**Table 12.** Coefficients (Grades 11 and 12)<sup>a</sup>

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	.001	.054		.020	.984
Student self-confidence	.136	.052	.143	2.621	.009
1 Impact of the teacher	-.297	.056	-.302	-5.327	.000
Perceptions of assignments	-.217	.055	-.222	-3.921	.000
Intention to pursue further study	.129	.055	.129	2.362	.019

a. Dependent Variable: Interest in STEM

Moreover, if grade is used as a control factor and the analysis is repeated only for secondary Qatari students (grades 11 and 12), interest in STEM is significantly determined by the two variables only impact of the teacher (0.000) and perception of homework assignment (0.004). A difference exists and grade level is significant in explaining and predicting variation in STEM (Table 12).

This study focused on the factors that predict students' interest in a STEM degree or profession. Overall, four main influences were identified in this research: the teacher, perceptions of homework assignments, self-confidence and intention to pursue further study in a STEM degree or profession. The results reveal that these four influences intersect with both gender and grade level, and these findings are consistent with other studies that have shown that these factors shape student interest in STEM fields.

Based on the findings from this study, interest in STEM appears to be significantly predicted by the impact of the teacher for both male and female Qatari students in preparatory and secondary schools. This is consistent with results from other research showing that teacher demographics influence children's interest in STEM and whether young adolescents major in STEM fields (Maltese & Tai, 2010; Stearns et al., 2016). Teacher influences range from helping students improve self-confidence and academic performance to optimizing student exposure to math and science courses (Wang, 2013).

This study further reveals that the results regarding homework assignments are highly significant for Qatari students - boys and girls alike - at preparatory and secondary schools. Evidence from existing literature confirms the value of using coursework in general to improve and deepen students' knowledge and understanding of subject matter (Slapcoff et al., 2011). More specifically, the student data may be indicative of how homework assignments are viewed as appropriate vehicles for enhancing young people's interest in STEM subjects. Assignments are effective tools in motivating students to read materials prior to class, enable attentive classroom discussions, and offer valuable opportunities for working on challenging material and potential solutions to problems (Etlinger, 2014).

The data appear to suggest that self-confidence is an important predictor of student interest in STEM, especially as it intersects with the gender and grade level factors. Stated differently, students' self-confidence is

associated with their intent and motivation to engage in a STEM degree or occupation (Rittmayer & Beier, 2008). The results of this study confirm a gender gap associated with self-confidence that affects interest in STEM where male, but not by female, Qatari students' self-confidence helps to predict their interest in fields. Females' underrepresentation in STEM fields has been ascribed to their preference of jobs that are people-oriented rather than less things-oriented ones because women generally tend to choose careers that allow them to use their communication and social skills and abilities (Su & Rounds, 2015).

The present study also shows that self-confidence intersects with grade level in predicting interest in STEM. It is clear that in the case of students in lower levels of educations (only grades 8 and 9 in this study) self-confidence is a predictor of interest and eventual entrance into a STEM degree or profession in STEM. There is evidence that confirms a child's level of education plays an important role in a child's interest in STEM (Maltese & Tai, 2011). This shows a pipeline for the STEM workforce should start early in life, and strong links have been observed between early interest in STEM and eventual STEM professions (Tai, et al., 2006).

This study further suggests that intent to pursue further study is significantly predicted by grade level. This pertains specifically to Qatari students in lower (preparatory) levels of education (i.e. grades 8 and 9). This is in agreement with findings concluded from other research which indicates that children's early interest in STEM is an indicator of the likelihood they would complete a college degree in STEM (Becker & Park, 2011; Hayden et al., 2011). This points to the importance of promoting student interest in STEM at the early stages of education. Student intention to pursue post-secondary study as a predictor of student intent to continue post-secondary studies in STEM can be attributed to possible support from family members, peers and friends or school-related factors (school reputation, school climate, etc.), as evidence by available research (Forbes & Skamp, 2014; Price et al., 2003; Sjaastad, 2012).

### LIMITATIONS OF THE STUDY

One limitation of this study is that it relied on utilizing a survey research questionnaire administered over a four-week period to examine different aspects of schooling, one of which is student interest in STEM. While this study tried to explore preparatory and secondary school students' interest in STEM in Qatar, it would benefit from using a survey that taps different developmental stages of student interest in STEM fields. Hence, replicating this study using longitudinal data is highly recommended. Another limitation of this research has to do with the focus of our research that is limited to discussing STEM as an object of interest within the school context. With this being the case, a line needs to be drawn between the way STEM subjects are perceived in society as well, that is outside the school setting.

### RECOMMENDATIONS

To meaningfully engage students and at the same time raise achievement in the STEM fields for all K-12 students, there is need to foster high-quality teaching with world-class curricula, standards, and assessments of student learning that align with Qatari student needs and abilities. To attain this goal, a possible option to consider would be curriculum materials that can be modeled on world-class standards, including the introduction of new methods of teaching and learning as well as the use of digital technologies that enhance STEM education.

A hands-on approach to teaching and learning STEM subjects that increases student achievement in STEM fields needs to encourage real engagement with fundamental science concepts and principles should also be enhanced through application to real-life situations and practical work. Practical laboratory experience for both middle school and high school students in particular is of crucial value. In parallel with this, inquiry-based learning must be emphasized at all K-12 levels of schooling and individualized and group experiences using project based learning inside and outside the classroom through experiences such as science fairs, robotics contests and STEM Olympiads.

To ensure excellence in STEM education, there is urgent need for STEM teachers who possess deep content knowledge in STEM subjects along with good mastery of the pedagogical skills required for teaching these subjects

well. Support for STEM teachers should be provided so that they are ready to meet the challenges of teaching in the STEM classroom; particular emphasis must be placed on provision of ongoing quality professional development and the necessary resources to effectively teach at all levels.

Last but not least, career guidance should be available especially at the secondary school level to help adolescents become aware of potential STEM careers and connect their future career decisions to their educational decisions. Counselling programs can be useful in enhancing student engagement in STEM fields and promoting STEM careers while assisting students to make a smooth transition into college. Preparing students for this transition begins both in the classroom and through guidance programs, and counselors hold key roles in stimulating interest and encouraging young adolescents' exploration of career options in STEM fields.

### CONCLUSION

Science, technology, engineering, and mathematics (STEM) are closely tied to the economic success and prosperity of Qatar and are vital to Qatar's transition to the knowledge economy and competitiveness. Strong STEM skills are a key element of a well-rounded education. Yet, strikingly few Qatari students seek or obtain a STEM bachelor's degree. As is reported in the Qatar University Book of Trends 2017, student interest in STEM is increasingly recognized as a critical key to increasing the number of students who graduate with a degree in a STEM field or aspire to a STEM career (Qatar University, 2017).

The dearth of Qatari graduates in STEM subjects adds another dimension to the challenge and complexity of attracting and retaining students in STEM domains. This speaks to the policy and decision makers particularly since Qatar is investing hefty amounts of money in a strenuous attempt to move from reliance on hydrocarbon resources and make a smooth transition to a society based on the knowledge economy.

In line with the Qatari National Vision 2030, findings of this research can be utilized to inform decision and policy makers as well as educators in Qatar in designing programs that promote, support and encourage students' interest in STEM. Given the findings of this study, more work is needed to promote STEM fields and trigger children's interest and engagement in STEM subjects at Qatari schools.

The focus of our research is limited to discussing STEM as an object of interest within the school context. With this being the case, it would also be useful to investigate the way STEM fields are perceived in society as well, that is outside school setting.

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