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Secondary School Students' Interest in STEM Careers in Qatar

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Abstract: In light of the high demand for skilled professionals and talents internationally, STEM skills carry special significance in today's competitive economy. Drawing on the Social Cognitive Career Theory (SCCT) and insights gleaned from the extant literature, our study sought to investigate the factors that are likely to predict students' interest in a STEM-related career in Qatar. An online survey was administered online via computer-assisted web interviewing (CAWI) and paper-and-Pencil Interviewing (PAPI) during the Spring term of 2021. Data was gathered from a sample of 1505 secondary school students, including 278 in grade 11 and 764 in grade 12) students in Qatar. Findings concluded from a two-level mixed-effects logistic regression revealed statistically significant differences based on students' age, nationality, and support from the family. Non-Qatari (expatriate) students attending private schools are significantly more likely to display interest in STEM-related careers. Additionally, taking a STEM course and teachers' use of experiments emerged as additional significant factors that affect student interest in a STEM-related career in Qatar. Our results point to the need for instruction to incorporate and emphasize practical activities to encourage students to engage in real-life STEM learning.

Keywords: career interest; mixed-models analysis; Qatar; secondary school students; STEM

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1. Introduction

Despite the limitless possibilities that different fields of science provide, a real challenge the modern world is confronted with is the paucity of people with the right skills in the different domains of science, technology, engineering, and math (STEM). The recent outbreak of COVID-19 exposed the vulnerability of public services in many societies and heightened the need for highly skilled professionals [1]. At the same time, the unprecedented and multi-faceted challenges the pandemic engendered demand viable solutions, because "success is driven not only by what you know, but by what you can do with what you know" and this entails the "skills that students learn by studying science, technology, engineering, and math—subjects collectively known as STEM" [2].

A primary concern of many governments is the shortage of professionals who possess the critical skills essential for the needs of an increasingly demanding marketplace [3]. Demonstrably, the COVID-19 pandemic has intensified the importance of "critical STEM literacy comprising STEM knowledge, skills and understanding necessary to engage with concepts and processes impacting personal health decisions and engaging with interactions of STEM" [4] (p. 353). Nowadays, governments are required to provide an education that integrates "the cognitive domain of critical reflection (head), the affective domain to relational knowing (heart) and the psychomotor domain of deep engagement (hand)" [5] (p. 521).

The purpose of the present study was to explore the factors likely to determine secondary school students' interest in pursuing STEM career pathways in Qatar, concentrating on the fields of math, science, and engineering as examples. The study explores whether

influences found to shape interest in STEM professions in prior international research—specifically studies undertaken in Western contexts—also apply in the context of Qatar and the larger Gulf Cooperation Council (GCC) states (Qatar, Kuwait, Kingdom of Saudi Arabia, United Arab Emirates, Bahrain, and Oman). By looking at students' STEM-related career interests in Qatar, our study is unique in offering an alternative Arab, Middle Eastern perspective on salient predictors of student interest in STEM careers; it also provides a new insight into how resource-rich GCC countries, including Qatar, strive to transform into knowledge–based societies and have, as a result, committed significant financial investments to address STEM skill and talent gaps.

This paper is structured as follows. The Section 2 provides contextual information to set the scene and clarify key components of the study. The Section 3 synthesizes and critically evaluates relevant work dealing with interest in STEM and STEM-related careers, drawing on the Social Cognitive Theory (SCCT) as a theoretical model for the current study. Section 4 offers a detailed description of the research design and the methods utilized in our research, including the data collection and the mode of analysis. The study's results are presented in Section 5 and the section that follows provides a detailed discussion of these results.

1.1. STEM Fields of Study and Careers in Qatar

Many in education, government, and industry circles argue that the need for professionals in STEM fields in Qatar is in crisis [6]. While demand for STEM professionals in the country is very high, the number of citizens with the education and training required for sustaining the industries that are vital to the economy is very low. The mismatch between education and job market needs has resulted in a situation where a very high proportion of unskilled and semi-skilled citizens are employed in the public sector [7]. Consequently, the private sector has had to rely on foreigners to fill the gap in STEM professions. With a deficit in the number of young people who are studying and contemplating a career in STEM, Qatar will continue to rely heavily on expatriate labor. Similarly, whereas expectations for student performance in STEM subjects are high, their scores in international math and science tests are lagging behind international standards [8]. Test score results from standardized international tests, including the OECD Program for International Student Assessment (PISA) and the Trends in International Math and Science Study (TIMSS) reveal that students in Qatar are falling behind in math and science at all school levels and are not prepared for post-secondary education [9].

1.2. Qatar's Participation in STEM Education and STEM Professions

Looking at higher education, Qatar's participation in the fields that are central to the knowledge economy (e.g., computer science, engineering, health, math) is limited. Demonstrably, Qatar appears to have the highest proportion of citizens (49%) enrolled in non-STEM disciplines (e.g., the Social Sciences, Business, Law, and Services), compared to developed nations, such as Norway (33%), the United Kingdom (32%), Finland (30%), and South Korea (28%), as is noted in the Ministry of Development Planning and Statistics (2018). By contrast, enrolment in STEM disciplines (e.g., Health and Welfare, Engineering, Math, and Computer Science), is the lowest in Qatar (30%), compared to top-performing countries: Finland (51%), South Korea (47%), Norway (42%), and the United Kingdom (42%) [10] (p. 187).

Qatar University, the only public (government-funded) university in Qatar, currently hosts more than 23,000 registered students. Of these, nationals make up 66%, and females 77%. At present, Qatar University is offering the widest range of programs in the country, including 12 colleges and 45 undergraduate programs [11]. Available statistics for the university's enrolment trends over the past decade show significant gender-based differences in bachelor's degree program preferences [12,13]. Over the last 10 years, males display an increasing enrollment trend in the disciplines of Law, Mass Communication, and Engineering. By contrast, females display an intermittent enrolment trend, shifting

from languages (Arabic and English) and History to Primary or Secondary Education, Policy, Planning, and Development. Interestingly, Law and Mass Communication have consistently remained the top two academic programs registered for.

1.3. College Transition and Retention

Students' smooth transition from K-12 to college requires overcoming multiple academic, social, and cultural difficulties to cultivate the attitudes, experiences, and skills necessary for success [14]. Available research reveals that the most dramatic drop out rate among college and university students occurs during their early years of study, mainly because of their failure during this transition period [15,16]. Qatar University Fact Book Statistics provided for students graduating with a bachelor's degree indicate an increase in the number of STEM graduates between 2015/2016 and 2018/2019, followed by a declining trend from 2018/2019 to 2020/2021 [13] (see Figure 1).

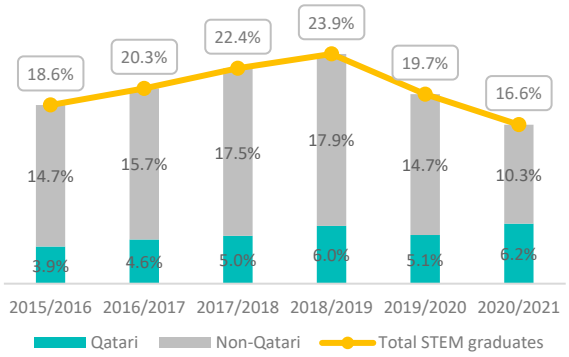
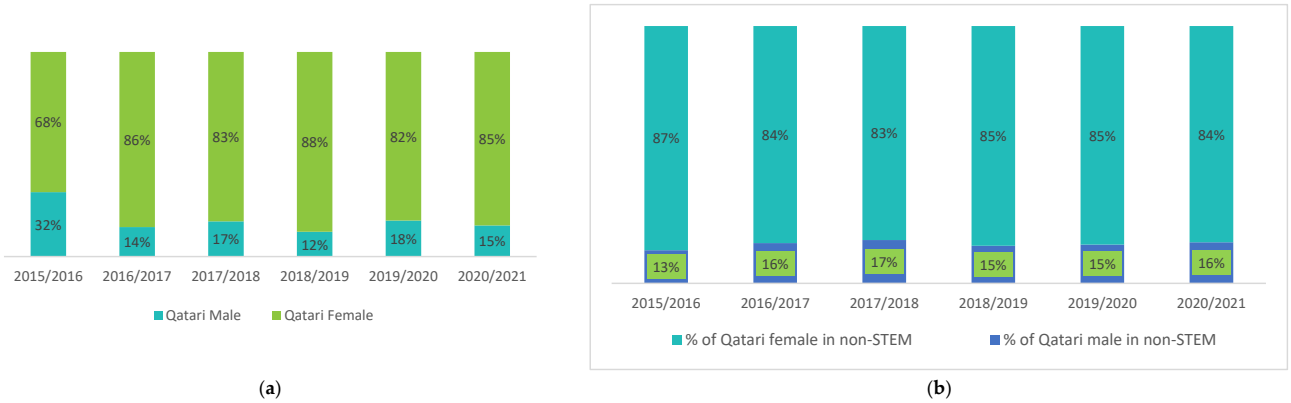


Figure 1. Qatar University graduates with a bachelor's degree in STEM * (by nationality). Adapted from the Office of Strategy and Development [13]. * STEM majors: biology, biomedical sciences, chemistry, environmental sciences, statistics, public health, engineering, and pharmacy.

Data reported for Qatar University's graduates, for example, demonstrates a clear gender gap in STEM among Qatari students, with female graduates with a bachelor's degree in STEM far outnumbering males (Figure 2a). Interestingly, since 2016/2017 the rate of male STEM graduates has steadily remained below 20 percent of graduates with a STEM degree, compared to females, by a ratio of 1 to 4.



(**a**) (**b**)

Figure 2. (**a**) Qatar University graduates with a bachelor's degree in STEM (Qatari students, by gender). Adapted from the Office of Strategy and Development [13]. (**b**) Qatar University graduates with a bachelor's degree in non-STEM (Qatari students, by gender). Adapted from the Office of Strategy and Development [13].

The figure below shows the proportion of male and female Qatari students in non-STEM fields. With respect to non-Qatari graduates, statistics show a different gender-related

graduation pattern. For instance, as is displayed in Figure 3, there is a close to equal gender split in STEM-related graduation rates for 2018/2019 and 2019/2020 (51% female graduates and 49% males).

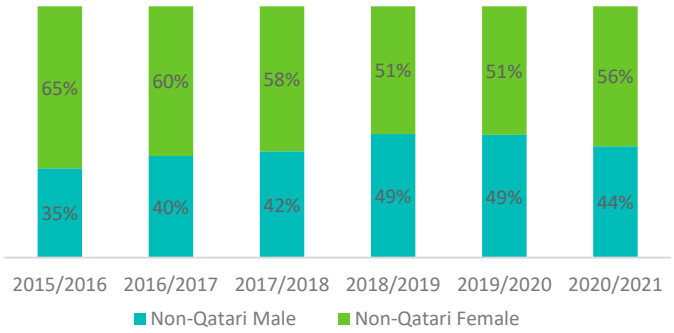


Figure 3. Qatar University graduates with a Bachelor's degree in STEM (non-Qatari students, by gender). Adapted from the Office of Strategy and Development [13].

Qatar University's graduation trends further reveal an evident discrepancy in the rates of Qatari versus non-Qatari graduates holding a STEM bachelor's degree. Official statistics further suggest that the number of Qataris who received a bachelor's degree in STEM between 2015/2016 and 2019/2020 stayed at a worrying 10% or lower; the share of non-Qataris who earned a STEM bachelor's degree over the last five academic years (2015/2016–2019/2020), has consistently reached a point more than four times higher that of Qataris each year.

Figure 4 below offers statistical data for graduates with a bachelor's degree from three popular government institutions of higher education in Qatar: Qatar University, Qatar Community College, and Ras Laffan College.

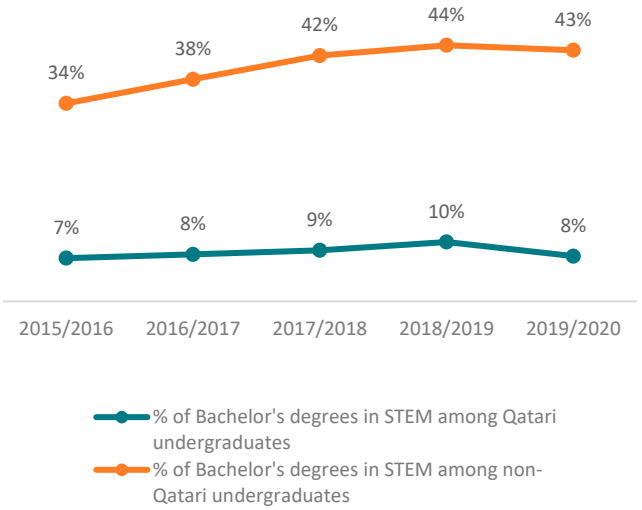


Figure 4. Percentage of undergraduates with STEM degrees in Qatar's institutions of higher education over the last five years*. Adapted from the Qatar Planning and Statistics Authority [17]. * As a percentage of all undergraduate students in Qatar.

1.4. Literature Review

Research asserts that STEM education plays a crucial role in developing and expanding human capital in domains that are critical to a nation's competitiveness and economic prosperity [18]. As the world is trying to adjust to the aftermath of the pandemic, i.e., the "next normal" [19]—also referred to as the "new normal", [20]—persistent uncertainties underscore the vital role of STEM skills and knowledge for the next normal [21]. Today's job

market demands highly skilled professionals capable of dealing with increasingly complex situations and performing complicated tasks. Therefore, the need for a creative, innovative, and highly skilled workforce is on the rise and will continue to increase [22].

Although little consensus has been achieved as to the specific fields that fall within STEM, science, technology, engineering, and math are all placed under the broad category of the knowledge economy. Designated as STEM [21] or STEMM (STEM and medicine) [23], these fields encompass occupations identified as being key to global competitiveness and central to modern society. As Rosicka stated, "Definitions in the literature cover the full spectrum from a mix–and–match or continuum approach, inter- and multi-disciplinary, through to a fully integrated view of STEM education." [24] (p. 4). In the present study, math, science, and engineering constitute the main focus of our investigation and are therefore grouped as representative examples of STEM.

Students' Interest in STEM

Interest is a multidimensional construct that involves both affective and cognitive dimensions [25]. In the context of education, the attitudes students hold toward an academic subject reflect a composite of both self-efficacy and expectancy-value beliefs, two important subcomponents of their motivation to learn [26]. Past research has shown that students with high levels of self-efficacy and expectancy-value beliefs are more likely to engage in post-secondary STEM study [27]. Current research shows that early interest in STEM is key to later career choices [28,29]. More specifically, strong linkages have been found between students' early career aspirations and their eventual entrance into a STEM career. For example, using data from the Longitudinal Study of American Youth (LSAY), Miller and Kimmel found that 12th-grade students' plans to enter a STEM career have a greater impact on their eventual entrance into a STEM career than 12th-grade student achievement in science or math [30]. In another analysis using the LSAY data, Ing and Gibson found strong associations between 7th graders' attitudes toward math and science and their eventual entry into a STEM career [31].

Interest in successful STEM education has prompted researchers to explore the factors that lie at the root of student interest in STEM degrees and professions. Previous scholarship in STEM education has identified a range of important influences that affect the interest students display in pursuing STEM careers. At the student-level, many studies have shown that individual characteristics are strong determinants of student interest in a career in STEM areas. For example, students' affective attributes such as motivation, self-confidence, and personal goals play an important role in how well they do in their STEM subjects at school [32].

Students' academic performance and interest in STEM also have been found to enhance their aspirations to pursue a career in STEM [29]. As Modi and colleagues noted, highly achieving students experiencing exposure to STEM develop an interest in STEM-related careers [33]. Other research underscores the importance of students' self-efficacy and favorable attitudes toward STEM in shaping their pursuit of a future career in STEM fields [34]. Parental influence has also been recognized as an important predictor of a child's interest in future STEM careers. Specifically, a study conducted by Mau and Li concluded that parental level of education, occupation, and income influence their child's aspirations for a career in STEM [35].

Another theoretical thread within the literature on STEM points to the impact of cultural stereotypes in shaping men's and women's attitudes and perceptions of careers in STEM [36]. Social stigma and gender-based stereotypes, for instance, were also found to intersect with gender and career aspirations. For example, work by Lindemann and others revealed that interaction between institutional culture and gender stereotypes affects women's persistence and choice of a STEM major and eventual career [37]. Other research by Maltese and Cooper indicated that females tend to be less likely to engage in STEM career paths, compared to males [38].

1.5. Theoretical Framework

1.5.1. Social Cognitive Career Theory

Many of the explanatory variables reported in previous research on student interest in STEM degrees and careers emanate from the broader literature that uses social cognitive career theory [39], which was derived from Bandura's Social Cognitive Theory [40]. Originating from a constructivist tradition, the social cognitive career theory (SCCT) highlights the thoughts, beliefs, and personal and environmental factors shaping people's interests and the choices they make. SCCT theorizes that self-efficacy, outcome expectations, and goal setting regulate a person's career decision-making [39], with self-efficacy referring to people's confidence in their ability to perform a specific task while outcome expectations are the results that they expect to emanate from performing a particular behavior. Goal orientation involves the process whereby an individual establishes a goal or outcome that serves as the aim underlying their actions. In this study, SCCT provided a theoretical framework for determining the factors likely to influence student educational (and occupational) interests. The study drew on SCCT to examine the potential relationship likely to exist between students' interests and self-efficacy, outcome expectations, and goal setting, taking into account their individual-level characteristics and related contextual factors. Looking at the literature on student interest in STEM from the vantage point of SCCT aided in understanding the influences that encourage or deter students' entrance into STEM fields of study.

1.5.2. Problem Statement and the Research Questions

COVID-19 has irrevocably altered the job market landscape, laying bare the urgent need for highly sought-after hard and soft skills [41]. For example, a report by the International Labor Organization notes that "lessons learned during the recent phase of the pandemic" highlight the importance of three skill sets: "first, the importance of remote learning, including for the acquisition of practical skills, and preconditions for its high-quality provision; second, the importance of specific socio-emotional skills and behavior that facilitate resilience to crises; and, third, preparedness for future shocks." [42] (pp. 10–11). Two questions guided our study:

1. What background (household) and contextual (school) factors are likely to predict students' interest in a STEM-related career in Qatar?
2. Does student gender explain significant differences between schools on students' career interests?

2. Materials and Methods

2.1. Survey Design

For the purpose of this study, a survey was employed to collect data from secondary school (Grades 11 and 12) students in Qatar. The survey was built on comprehensive and previously validated instruments [43] to assess students' interest in a STEM career. Owing to the COVID-19 pandemic, questionnaires were first administered online via computer-assisted web interviewing (CAWI) during Spring 2021. Since the response rate was low, we utilized Paper-and-Pencil Interviewing (PAPI) to increase the number of responses. The Social and Economic Survey Research Institute (SESRI) of Qatar University was commissioned to distribute the questionnaires, which consist of four parts. Part One looks at student demographics (gender, age, nationality, parental education, and employment, the school attended and grade level, and the track attended (STEM or non-STEM)). Part Two focuses on students' STEM interests in math, science, and engineering. Part Three includes items on barriers to STEM, including society's perceptions, instruction and teaching materials, and COVID-19. Part Four examines students' future career aspirations, which is the focus of this study.

2.2. Procedure and Sample

The researchers utilized a sampling frame prepared by Qatar's Ministry of Education, including government and private schools in Qatar. This frame comprised 180 schools: 83 public and 97 private schools, totaling 24,992 (11th and 12th grades) students. The frame was broken down into eight different strata categories. Within each stratum, students were chosen randomly based on two-stage sampling. Stage one involved the selection of schools using a probability that is proportionate to their size to permit equal chances of student selection from each school. In stage two, one class was randomly chosen for each school grade, with all students in the class included in our survey. The design of this complex sampling was clarified in the analysis of the data to reduce bias and enhance the efficiency of statistical estimates. In total, 1505 secondary school students (Qatari and non-Qatari) participated in the study: 728 (48.8%) in grade 11 and 764 (51.2%) in grade 12. The sample consisted of female students (n = 908, 60.6%) enrolled in private schools (n = 973, 64.6%) and studying a STEM track (n = 1081, 73.9%). Table 1 presents a summary of the demographic characteristics pertaining to the sample used in our study's analysis.

Table 1. Demographic composition of participants (n = 632).

Variables	N (%)
Gender	
Boys	260 (50%)
Girls	372 (50%)
Nationality	
Qatari	123 (35%)
Non-Qatari	509 (65%)
Average age	
11th grade	15
12th grade	16
Grade level	
11th grade	328 (54%)
12th grade	304 (46%)

After securing approvals from the Ministry of Education and Qatar University's Internal Review Board, a letter requesting permission to implement the survey was sent to each participating school. Students and their parents were informed about the purpose of the research and were assured participation in the study was voluntary; they were also given assurance their responses would be kept confidential.

2.3. Measures

Students' STEM career interest is the dependent variable for our study's statistical analysis. In the questionnaire, students were asked: "What kind of work do you want to pursue in the future?" They were instructed to choose one answer from a list of 16 different careers, including (1) The military; (2) The police; (3) Accountant; (4) Teacher; (5) Lawyer; (6) University Professor; (7) Medical Doctor; (8) Nurse; (9) Clerk; (10) IT Technician; (11) Physical Therapist; (12) Chef; (13) Scientist; (14) Businessman/Businesswoman; (15) Diplomat; (16) Engineer. Additionally, the list contained an "Other" option, with an open-ended "please specify" space) and an "I do not know" option. In our analysis, students' interest in a future STEM career was treated as a dichotomous variable assigned the value of 1 if a student selected "STEM career" from the list or the value of 0 where a "non-STEM career" was selected. Our analysis identified seven STEM-related occupations: accountant, engineer, IT technician, medical doctor, nurse, physical therapist, and scientist.

2.4. Independent Variables

Taking STEM course. Students were asked, "Are you taking STEM courses?" This question was treated as a dichotomous variable taking a value of 1 if the student selected "Yes" or zero for "No".

Interest in math. Students were asked to indicate to what extent they agree or disagree with five statements related to math: (1) Math has been my worst subject; (2) If I study hard, I will do well in math; (3) I would consider a career that uses math; (4) I know I can do well in math; (5) I can handle most subjects well, but I cannot do a good job with math. Interest in math is a construct created from five categorical variables using Principal Component Analysis (PCA). The variables were measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) for each statement. The last two statements (4 and 5) were reverse-coded.

Interest in science. Students were instructed to specify to what extent they agree or disagree with five statements related to science: (1) Science has been my worst subject; (2) If I study hard, I will do well in science; (3) I would consider a career that uses science; (4) I know I can do well in science; (5) I can handle most subjects well, but I cannot do a good job with science. Interest in science is a construct created from five categorical variables using PCA. The variables were measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) for each statement. The last two statements were reverse-coded.

Interest in engineering. Students were asked to determine to what extent they agree or disagree with 5 statements related to engineering: (1) If I learn engineering, then I can improve things that people use every day; (2) I am interested in what makes machines work; (3) Designing products or structures will be important for my future work; (4) I am curious about how electronics work; (5) I would like to use creativity and innovation in my future work. Interest in engineering is a construct created from five categorical variables using PCA. The variables are measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) for the five statements above.

Society's perception of STEM. Students were required to indicate to what extent they agree or disagree with four statements: (1) Qatari society has a positive opinion of STEM pathways for males; (2) Qatari society has a positive opinion of STEM pathways for females; (3) Qatari society promotes success stories of males in STEM; (4) Qatari society promotes success stories of females in STEM. Society's perception of STEM is a construct created from four categorical variables using PCA. The variables are measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) for each of the four statements above.

Family support. In the questionnaire, students were asked "Please read the following statements and indicate to what extent you agree or disagree" and were given three options to select from: (1) My family encourages me to follow STEM pathway; (2) My family participates in activities involving STEM (magazines, television programs, visits to museums, etc.); (3) In my family, we have conversations about what we are doing in school. Family support is a construct created from three categorical variables using PCA. The variables are measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) for each statement. Teaching with experiments. Students were instructed to indicate to what extent they agree or disagree with the statement: "My teachers use experiments in the classroom to explain the subject". This is a categorical variable measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree).

2.5. Control Variables

Gender was used as a binary variable, with a value of 1 for females and 0 for males.

Nationality also was employed as a binary variable, with 1 for Qataris and 0 for non-Qataris.

Age is a continuous variable created by subtracting 2019 from the year of the student's birth. Since the variable age has an influence on the dependent variable [27], it is included in the model in order to better measure the influence of independent variables. School grade (level). In our analysis, school grade was treated as a binary variable assigned the

value of 1 for grade 11 or 2 for grade 12. Parental education level. Students were asked to indicate their father's/mother's level of education based on a list of eight options: (1) Never joined school; (2) Elementary; (3) Preparatory; (4) Secondary; (5) Post-secondary diploma; (6) Bachelor's degree; (7) Master's degree; (8) Ph.D. Parental education level is a categorical variable measured on eight education level categories. The variable was dichotomized into 1 for "Bachelor's degree or higher", and 0 for "less than a bachelor's degree".

2.6. Multi-Level Mixed-Effects Analysis for Students' Interest in STEM Careers

In the data structure, students were nested in schools and, therefore, a multi-level was needed to capture the unobserved heterogeneity in the data [44]. This heterogeneity is attributed to students (level one effects) and/or schools (level two effects). As such, a multi-level analysis was deemed adequate to provide more reliable estimates than a single-level analysis. The mixed-effects analysis includes both fixed effects and random effects: while the former technique captures the relationship between the outcome variable and independent variable(s) for the whole population, the latter captures variation between and within clusters (schools) [45].

Thus, the mixed-effects analysis is a multi-level analysis that considers the nested structure of the data [46]. Since the outcome variable is binary (STEM career), the two-level mixed-effects logistic regression was employed. When comparing the single-level model with the multi-level model, the Likelihood Ratio Test (LRT) indicates that the multi-level model is better than the single-level analysis as it fits the data (the p-value of a chi-square distribution is significant at a 5% level) [47]. The intra-class correlation (ICC) is a measure of between-group variance and its value ranges from zero (indicating no evidence of nesting effects in level 2) to one (indicating that all the variance in the model is caused by the nesting, which means no variance at level 1) [47].

2.7. Specification for the Two-Level Mixed-Effects Logistic Model

$STEMcareer_{ij}$ is the outcome variable and corresponds to the interest of student i in school j in STEM careers, β_0 represents the overall mean of the outcome variable across all groups (schools); v_j corresponds to the random intercept for the school j (school-specific random effects); v_{j1} is the random slope for the school j (school-specific random effects for female student) and $\eta_i j$ corresponds to the error term. The model includes the variables of age, grade level, STEM course, father's education, mother's education, interest in math, interest in science, interest in engineering, society's support, familial support, and teaching with experiments. The interaction term between gender (female) and nationality (Qatari) was excluded from our analysis since its effect is not significant in all specifications.

$$\begin{aligned} STEMcareer_{ij} = \; & \beta_0 + +\beta_1 age_{ij} + \beta_2 Grade_{ij} + \beta_3 STEMcourse_{ij} \\ & + \beta_4 Fatheredu_{ij} + \beta_5 Motheredu_{ij} + \beta_6 MathInterest_{ij} \\ & + \beta_7 ScienceInterest_{ij} + \beta_8 EngineeringInterest_{ij} \\ & + \beta_9 SocietySupport_{ij} + \beta_{10} FamilySupport_{ij} + \beta_{11} Teaching_{ij} \\ & + v_j + v_{j1} female_{ij} + \eta_i j \end{aligned}$$

2.8. Data Screening

The original dataset was in Stata format (version 16.1). Data screening to check for outliers and missing data was conducted using R Studio (version 4.0.3). The original dataset includes 1505 observations and 39 schools. Missing values were imputed using multiple imputations through the mice package (Multivariate Imputation by Chained Equations) which is suitable for ordered categorical data [48]. The default number for multiple imputations generates five imputed datasets [49]. Before the imputation step, individuals (cases) with more than 5% missing values were identified and excluded from the dataset using the subset function (843 observations excluded) and 201 observations with less than 5% missing values were imputed using the mice package. The next step was checking for outliers. Furthermore, using mahalanobis distance method [50],

30 multivariate outliers were identified and removed. The complete dataset without missing data and outliers contains 632 observations (students) and 25 groups (schools). In Stata, the multi-collinearity test was conducted using the Variance Inflation Factor (VIF) value and indicated the absence of multi-collinearity since the VIF value is below 2.5 [51].

In our study, we tested the data to check the suitability of the component analysis, utilizing the Kaiser–Meyer–Olkin (KMO) technique of sampling adequacy. The KMO measure is useful in testing the adequacy and variability of data to undertake component analysis. The Kaiser–Meyer–Olkin (KMO) value should be higher than 0.50 to ensure that the sample adequacy is acceptable to conduct the Principal Component Analysis (PCA) [52] and thus conduct an appropriate factor analysis. With KMO values ranging from 0 to 1, data values that are closer to 1 indicate high variability. In this study, the scale reliability for the five constructs (i.e., interest in mathematics, interest in science, interest in engineering, society's perceptions, and familial support) was assessed through Stata. Before conducting the PCA, the analysis starts with establishing the psychometric validity of the scale using Cronbach's alpha. The results indicate that the scale reliability for all five constructs was at an acceptable level with Cronbach's alpha of 0.70 or higher [27]. The PCA for each construct indicates that there is one component with Eigenvalue greater than one and eigenvector loading on each item is greater than 0.3 (see in Table 2). Stata calculates the score of each construct in the PCA using the command predict.

Table 2. Eigenvectors for the principal component of each construct (PCA Results).

Statements (Items)	Constructs				
	Interest in Math	Interest in Science	Interest in Engineering	Society Support	Family Support
Math has been my worst subject *	0.494				
If I study hard, I will do well in math	0.402				
I would consider a career that uses math	0.383				
I know I can do well in math	0.497				
I can handle most subjects well, but I cannot do a good job with math *	0.448				
Science has been my worst subject *		0.450			
If I study hard, I will do well in science		0.462			
I would consider a career that uses science		0.408			
I know I can do well in science		0.499			
I can handle most subjects well, but I cannot do a good job with science *		0.410			
If I learn engineering, then I can improve things that people use every day			0.390		
I am interested in what makes machines work			0.505		
Designing products or structures will be important for my future work			0.443		
I am curious about how electronics work			0.467		
I would like to use creativity and innovation in my future work			0.422		
Qatari society has a positive opinion on STEM pathway for male				0.483	

Table 2. *Cont.*

Statements (Items)	Constructs				
	Interest in Math	Interest in Science	Interest in Engineering	Society Support	Family Support
Qatari society has a positive opinion on STEM pathway for female				0.484	
Qatari society promotes success stories of male in STEM				0.520	
Qatari society promotes success stories of female in STEM				0.512	
My family encourages me to follow STEM pathway					0.588
My family participates in activities involving STEM (magazines, television programs, visits to museums, etc.)					0.559
In my family, we have conversations about what we are doing in school					0.584
Cronbach's alpha	0.741	0.772	0.814	0.836	0.608
KMO	0.728	0.741	0.806	0.651	0.641
Eigenvalue	2.515	2.698	2.873	2.688	1.687
% Variance explained	0.503	0.540	0.575	0.672	0.562

* Items were reverse coded. Items coded on a 5-point scale (1 = strongly disagree, 5 = strongly agree).

3. Results

3.1. Descriptive Results

As is shown in Figure 5, nearly half of the students displayed interest in pursuing a non-STEM career (46%) (Table 3). By contrast, 54% aspire to pursue the seven STEM occupations identified in our study. Of these, 41% indicated aspirations to become a medical doctor (23%) and an engineer (18%).

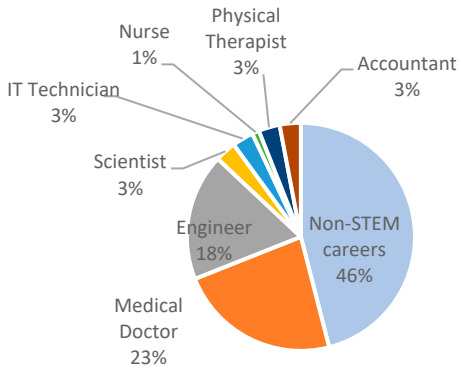


Figure 5. Interest in STEM careers (n = 632).

Question: What kind of work do you want to pursue in the future? (1) join the military; (2) join the police; (3) accountant; (4) teacher; (5) lawyer; (6) university professor; (7) medical doctor; (8) nurse; (9) clerk; (10) IT technician; (11) physical therapist; (12) chef; (13) scientist; (14) businessman/businesswoman; (15) diplomat; (16) engineer; (17) other.

In terms of gender (Figure 6), results indicate that health-related professions are very popular among female students. Specifically, nursing stands out as a career of exclusive interest to females (100%), followed by medicine (59%). By contrast, male students tend to aspire to careers in engineering (67%) and IT (68%).

Table 3. Student career interest (n = 632).

Occupation	Proportion (%)
Accountant	3.4%
Businessman/businesswoman	9.0%
Chef	0.3%
Clerk	4.0%
Diplomat	1.8%
Engineer	18.2%
IT technician	2.7%
Join the military	5%
Join the police	0.7%
Lawyer	5.2%
Medical doctor	23.1%
Nurse	1.2%
Physical therapist	2.5%
Scientist	2.6%
Teacher	3.8%
University Professor	2.8%
Other	12.8%

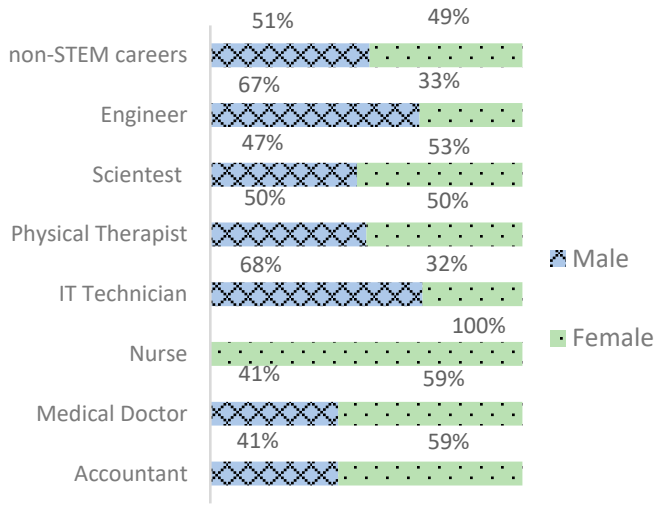


Figure 6. Interest in STEM careers by gender (n = 632).

Results for student nationality (Figure 7) point to a large discrepancy in students' career interests. Combined, our results reveal that Qatari students tend to be more interested in non-STEM professions (52%), compared to their non-Qatari counterparts. For this study's seven STEM careers, a clear nationality-based disparity depicts distinct student interests. Compared to non-Qataris, interest in STEM careers among Qatari students is low, especially in IT (9%), medicine (15%), physical therapy (19%), nursing (20%), and engineering (23%).

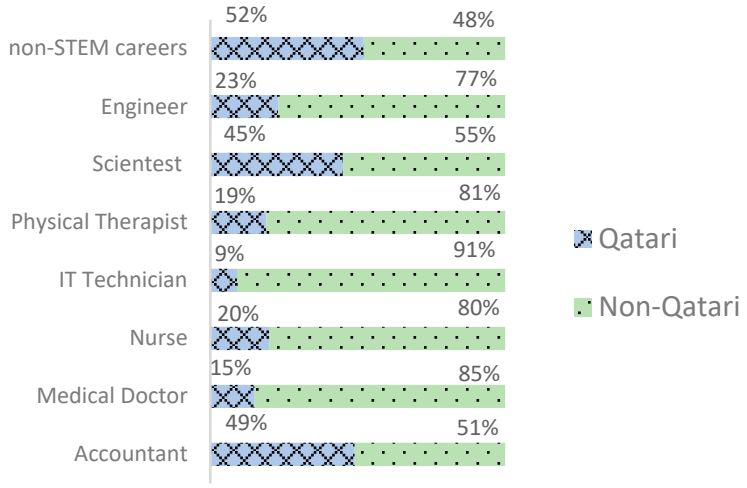


Figure 7. Interest in STEM careers by nationality (n = 632).

Moreover, results regarding school types in Qatar (Figure 8) disclose different response patterns for government and private schools. It shows that government school student aspirants to a STEM-related career outnumber their counterparts in private schools, except for IT (41%) and physical therapy (48%).

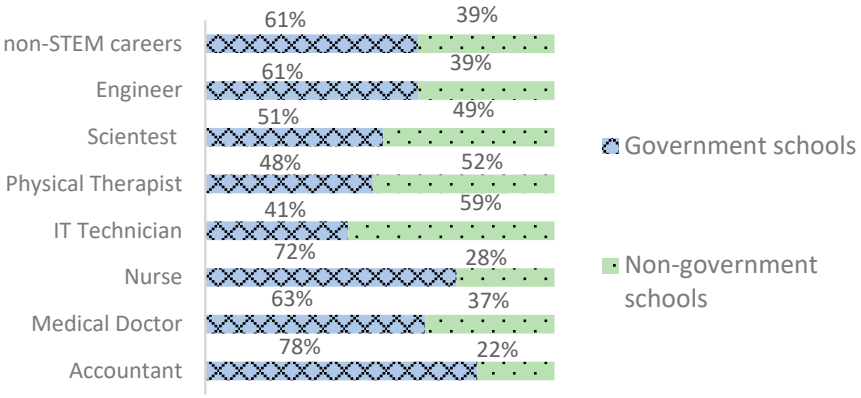


Figure 8. Interest in STEM careers by school type (n = 632).

3.2. Mixed-Effects Results

Table 4 shows the results derived from our analysis for all schools. In Table 4, the analysis started with estimating a single-level model (i.e., fixed effects for specifications 1–6). Then, school ID (level 2 variable) was added to estimate the random-effects part of the model. Both types (random intercept and random slope/coefficients) are estimated to measure any significant variation between and within schools in the outcome variable. The school ID variable represents school-specific random effects (i.e., between-school variation). For the random coefficients model, gender (level 1 variable) was added to represent school-specific random effects for female students (i.e., within-school variation). The rationale for selecting the gender variable for the random slope of schools is the gender gap addressed in STEM literature.

This section may be divided into subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

Table 4. Estimates for the two-level mixed-effects logistic regression model (all schools).

DV: Interest in STEM Careers	Individual Level (Fixed-Effects Part)						Multi-Level (Random-Effects Part)		
	Spec. 1	**Spec. 2**	**Spec. 3**	**Spec. 4**	**Spec. 5**	**Spec. 6**	**Spec. 7 Rand. Intc.**	**Spec. 8 Rand. Coeff. [a]**	**Spec. 9 Robust (Rand. Coeff.)**
Female	0.194	0.193	0.240	0.200	0.194	−0.031	−0.171	−0.042	−0.042
	(0.181)	(0.181)	(0.189)	(0.192)	(0.193)	(0.229)	(0.289)	(0.354)	(0.470)
Qatari	−1.073 ***	−1.056 ***	−1.026 ***	−1.033 ***	−1.022 ***	−1.088 ***	−1.042 ***	−1.094 ***	−1.094 ***
	(0.232)	(0.233)	(0.237)	(0.237)	(0.240)	(0.283)	(0.308)	(0.323)	(0.202)
Age	−0.219 *	−0.202 *	−0.171	−0.168	−0.184	−0.315 **	−0.291 *	−0.305 **	−0.305 **
	(0.113)	(0.114)	(0.114)	(0.114)	(0.117)	(0.138)	(0.150)	(0.154)	(0.128)
Grade level	0.228	0.226	0.180	0.180	0.228	0.316	0.304	0.239	0.239
	(0.201)	(0.201)	(0.206)	(0.206)	(0.209)	(0.243)	(0.272)	(0.283)	(0.276)
STEM course	1.096 ***	1.077 ***	0.942 ***	0.928 ***	0.825 ***	0.492 *	0.490 *	0.518 *	0.518
	(0.221)	(0.222)	(0.226)	(0.227)	(0.231)	(0.267)	(0.279)	(0.288)	(0.487)
Father education (bachelor or higher)	0.336 *	0.241	0.227	0.236	0.179	0.299	0.320	0.365	0.365
	(0.189)	(0.206)	(0.208)	(0.208)	(0.211)	(0.241)	(0.254)	(0.262)	(0.261)
Mother education (bachelor or higher)		0.229	0.184	0.177	0.106	0.085	0.028	−0.017	−0.017
		(0.196)	(0.199)	(0.199)	(0.202)	(0.232)	(0.247)	(0.254)	(0.211)
Interest in math			0.125 **	0.121 *	0.113 *	0.088	0.093	0.094	0.094
			(0.063)	(0.063)	(0.064)	(0.077)	(0.081)	(0.083)	(0.064)
Interest in science			0.140 **	0.127 **	0.092	0.083	0.108	0.123	0.123 *
			(0.058)	(0.059)	(0.061)	(0.074)	(0.078)	(0.080)	(0.064)
Interest in engineering			0.050	0.034	−0.007	0.050	0.034	0.031	0.031
			(0.057)	(0.058)	(0.060)	(0.071)	(0.074)	(0.075)	(0.060)
Society support				0.073	0.016	0.079	0.062	0.060	0.060
				(0.058)	(0.061)	(0.070)	(0.073)	(0.075)	(0.037)
Family support					0.272 ***	0.243 **	0.239 **	0.251 **	0.251 ***
					(0.082)	(0.095)	(0.097)	(0.099)	(0.091)
Teaching with experiments						0.413 *	0.479 *	0.448 *	0.448 *
						(0.237)	(0.254)	(0.258)	(0.261)
Constant	2.476	2.158	1.872	1.855	2.201	4.143 **	3.828 *	4.109 *	4.109 **
	(1.700)	(1.692)	(1.709)	(1.710)	(1.749)	(2.068)	(2.231)	(2.298)	(1.606)
School ID:								0.573	0.573
• Var(female)								(0.429)	(0.370)
• Var(constant)							0.273	0.201	0.201
							(0.194)	(0.206)	(0.271)

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. p-value for random coefficient model is less than 0.01. (Standard errors are in parentheses). [a]—Likelihood Ratio (LR) test indicates that the random coefficient model is better than the random intercept model (p-value < 0.05, significant). Spec.: Specification, Rand. Intc.: Random Intercept, Rand. Coeff.: Random Coefficients.

3.3. Results of Multi-Level Mixed-Effects Logistic Regression

We compare the random intercept with the random slope using the Likelihood Ratio Test (LRT). We find the result of LRT is significant (the test statistic is 4.34 on 1 degree of freedom, and the p-value is less than 0.05), yielding evidence that a student's gender affects student interest in STEM careers varies significantly across schools. The random coefficients model (specification 8) is selected for robustness check in specification 9. The random coefficient model indicates that the variation in the outcome variable between- and within-schools is significant. Moreover, the ICC statistic measures the size of variation in the outcome variable attributed to differences between- and within-schools. The ICC statistic estimate is 8% and provides evidence that there are variations in the outcome variable between schools due to clustering effects (level two effects).

The final model of the fixed-effects part (specification 6) indicates that gender has no significant effect on the outcome variable (student interest in STEM careers). Nationality has a negative effect, indicating that Qatari students are less interested in STEM careers (significant at 5% level). The interaction term between gender and nationality is not significant in all specifications, which may be attributed to the insignificance of gender's effect on the outcome variable. Age has a negative effect, with younger students being more interested in STEM careers than their older counterparts. Grade level indicates that students in grade 12 are more interested in STEM careers than those in grade 11. To clarify this point, it may be said that by looking at the sample as a whole, age has a negative effect; however, when looking at each grade level, grade 12 students are more interested in STEM careers than grade 11 are, which could be due to grade 12 students' likely exposure to the career fairs organized at schools.

The effect of taking a STEM course was significant in the specifications from 1–5, while its effect becomes insignificant in specification 6 at a 10% level. Regarding parental education, our results indicate that students with fathers holding a Bachelor's degree or higher tend to be more interested in STEM careers than those whose fathers have less than a Bachelor's degree. The mother's education level did not emerge as significant in any model at the 10% level. Overall, student interest in mathematics, science, and engineering has no effect on the outcome variable. Whereas society's support is not significant at a 10% level, familial support is significant at a 5% level with a positive effect.

The random-coefficients model (specification 8) provides similar estimates to the fixed-effects model (specification 6) with a decrease in significance levels of some variables (age and grade level). The effect size of some covariates (nationality, age, and the father's education) increases in the random-coefficients model (specification 8), compared to the fixed-effects part in specification 6, while there is a decrease in effect size of grade-level teaching with experiments. Such results indicate that allowing for variability in the outcome variable between schools (adding level 2 variable "school ID" to the model) and within schools (level 1 variable "female gender") provides reliable estimates that capture clustering effects and within schools due to school-specific random effects for female students.

The last model in specification 9 provides robust estimates for the random-coefficients model and shows the stability of some variables. However, there are changes in the significance level of the five variables in the last model. The significance level of the nationality and age variables increases from 5% to 1% level; grade level is insignificant at 10%; interest in mathematics and society's support becomes significant at 5% and 10% levels, respectively. Overall, the model (specification 9) indicates that the relationship between students' gender and their interest in STEM careers is not significant. When considering the effect of a student's gender on the outcome variable across schools, the results indicate that the variation between schools for the effect of gender on interest in STEM is estimated at 0.504.

4. Discussion

Several demographic and contextual factors have been found to predict students' STEM career aspirations. Our study revealed that the student's grade level, nationality, family support, taking a STEM course, and experiment-based instruction are important predictors of students' interest in a STEM-related career. These results corroborate findings from previous research, suggesting that demographics and background factors shape student career interests in STEM fields [30]. Interestingly, gender and household characteristics, especially parental education and profession, did not emerge as important predictors of students' interest in STEM career paths in this study.

Our results indicated that younger students are more likely to display interest in STEM career pathways, compared to their older counterparts. The extant literature on the topic yields inconsistent findings, revealing that student STEM career interests are not constant during their school years [52]. While some studies suggest that interest in STEM careers starts to develop prior to the secondary school level and evolves early during a student's adolescent life [53], other research notes this interest grows significantly when transitioning to secondary school [54]. Other studies reveal stable student interest across the different levels of secondary school [55].

Our results also disclosed that interest in STEM was significantly predicted by students' nationality, with Qatari students being less interested compared with non-Qataris. Arguably, whereas past research has explored how ethnicity and race characteristics affect students' STEM-related career paths, student nationality hasn't received sufficient attention in existing research [56]. The higher rates of STEM career interest among non-Qatari students may be partially interpreted considering Qatar's school system, which provides a wide range of international schools. For example, American, British, Canadian, French, and Scandinavian schools offer a selection of curricula that deliver year-long project-based courses and STEM-related clubs. High interest in STEM among non-Qatari students may

also reflect student aspirations to meet job-market demands. as prior research has shown, Qataris prefer public sector jobs and are, therefore, less inclined to join private sector employment [8].

The comparable lack of interest in STEM careers among Qatari students, especially males, may be understood against the socio-cultural background of Qatar and the other Arabian Gulf states. The GCC is home to an unrestrained rentier culture where citizenship determines the state's provision of welfare and allocation of social services and economic benefits, and the riches of GCC countries have created a rentier mindset that champions entitlements and nurtures unequal privileges [57], and state largesse and subsidized public services have made citizens "relatively passive" [58]. As Razzaz stated, "The model that the Arab rentier state represents is the antithesis of production" [59] (p. 5).

The job market in Qatar and neighboring GCC countries depicts an interesting situation that reflects real tension between the public and private sectors. The rentier culture in the GCC has engendered feelings of entitlement among citizens who compete for desired employment in the public sector, making this sector saturated with a national workforce that often lacks the skills potential that employers seek. By contrast, private-sector employment is mostly dominated by foreign workers [60]. Research has shown that high salaries, job security, low expected productivity, and better work conditions, such as shorter working hours, as important drivers that influence the choice of public sector employment by Arab nationals [61]. According to the World Bank [58], preference for public sector jobs has led to a public sector that is overstaffed with nationals that often lack the skills in demand by the job market. It is often argued that the prevalent rentier cultures have generated a weak private sector in the GCC states [62]. This study's results also indicated that family support is a predictor of student interest in STEM career paths, with a highly significant positive effect. Specifically, parents provide the closest inspiration to their children, thus influencing how they perceive STEM [63]. Indeed, positive associations have been identified between parental support and encouragement and their child's educational attainment and career aspirations [54]. Evidence from the literature confirms the role of parental influences, including their STEM-related knowledge and experience in predicting children's STEM career paths [29]. Findings from our study indicated that the father's education level emerged as a salient predictor of their child's interest in a STEM career. Students attending private schools and having a father who holds a bachelor's degree or higher are more likely to display interest in STEM careers. Whereas the existing literature stresses the role of parents' education in shaping children's career aspirations, the present study discloses the father's, rather than the mother's, influence [56].

Considering the demographic composition in Qatar, foreigners constitute a major portion of the population, currently standing at around 87% [64], and many of these are skilled Arab and Asian professionals working in education, health, services, transportation, petroleum, and other businesses. Whether the role of fathers' education in determining students' interest in future STEM careers is due to cultural or background influences is yet to be investigated. Future research is required to explore the potential differing impacts of mothers and fathers in predicting their child's STEM career aspirations.

Our results suggest that, depending on the type of school they attend, taking a STEM course is another important predictor of students' interest in STEM careers. Students with exposure to math in a government school and those exposed to science in private schools are more likely to show interest in a STEM career. Further evidence is needed to investigate whether or not early exposure to STEM at school is an indicator of the influence of classroom instruction in shaping student interest in future STEM professions. While information is lacking concerning why taking math and science courses emerged as drivers of students' STEM career interests respectively in government and private schools in Qatar, course experiences in both subjects may be viewed as underlying beliefs regarding STEM careers more generally. This finding may be interpreted as signifying that motivation, confidence, and ability may account for students' interest in STEM careers. There is evidence that suggests that favorable attitudes toward STEM courses drive students to consider STEM

career paths. As Fuesting and others remarked, exposure to STEM courses—including course content and course processes, that is "what is taught and how it is taught" [63] (p. 878)—predicts student motivation and achievement, both of which influence interest in STEM-related careers.

Our study's results further indicated that teaching with experiments has a positive effect on private school students' interest in STEM professions. Work completed by Wang and Degol points to the influence of teaching in enhancing students' academic achievement and self-confidence, which inspires their initial interest in STEM [27]. In-class laboratory experiments, along with other in-class factors such as hands-on and problem-based projects, spark students' interest in STEM careers [64]. According to LaForce and colleagues engaging in STEM-related problem-based projects fosters students' positive attitudes toward and interest in STEM [65]. Teaching that incorporates experiments and other practical activities enhances student learning outcomes [66] and is more motivating than traditional teaching methods and is a preferred option to students in Qatar, compared to traditional methods [67]. Despite multiple education reforms calling for promoting students' creativity and innovation skills to enable them to develop 21st-century skills, government schools in Qatar largely use traditional methods that stress rote learning and memorization. Consequently, opportunities for learning practices, including problem-solving and critical and analytic thinking are missed [68].

5. Conclusions

This study underscores the need for increasing the participation of skilled nationals in Qatar's workforce and hence the importance of STEM education for Qatar's sustainable development. It highlights the importance of enhancing the interest of students, particularly males, in pursuing STEM career paths in the country. Interestingly, the gender gap in student interest in STEM school subjects and future careers in Qatar is evident, for females vastly outnumber their male counterparts in most STEM disciplines. Representation in STEM disciplines in higher education remains heavily female-dominated and a host of reasons are often given to partly account for this.

First, many male students tend to take public sector jobs immediately after their high school graduation. Second, for cultural reasons, the students who decide to pursue their higher education abroad are more likely to be males; females are less likely because they would need to be accompanied by a male guardian. Third, there is an acute lack of compatriot role models to look at. Finally, in light of the rentier mindsets referred to above, many students lack the drive and motivation to study subjects that are perceived to require effort, hard work, and competitive performance. Results from this research revealed that the factors of school grade, nationality, and familial support are key predictors of students' interest in STEM professions in Qatar.

Our analysis and the findings derived from it offer important information for educators, policymakers, and school administrators and provide an empirical basis for school initiatives to foster better student participation in STEM domains. Specifically, educational policies should focus on strategies that target worrying low levels of interest in STEM fields of study and careers among Qatari students, especially those in government schools. An essential component of this is to improve students' academic performance in STEM school subjects, particularly those at pre-college levels.

Considering our results indicated that students' exposure to STEM in class and experimental teaching and learning influence their interest in STEM careers, targeted intervention programs further need to improve student STEM attitudes and interest in STEM careers, especially in government schools. Practical and hands-on activities should be an integral part of instruction because they are effective ways of teaching STEM and have been proven to increase students' positive attitudes and interest in STEM studies and professions. Future research that employs qualitative data would benefit scholarship on students' motivations to study STEM as well as their aspirations to STEM professions in Qatar and beyond. In par-

ticular, longitudinal studies will provide rich insights into how students view STEM careers and the motivations that may spark their interest in and aspirations for such professions.

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