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# Exploring Teachers' Perceptions of the Barriers to Teaching STEM in High Schools in Qatar

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**Abstract:** Understanding teachers' attitudes and perceptions of STEM teaching is a key pathway to enhance effective STEM teaching. Inarguably, teachers are the cornerstone of educational quality and play a central role in students' academic performance. Specifically, the pedagogical strategies teachers employ and their effective use in the classroom are strong determinants of students' enrollment or retention in STEM fields of study and eventual careers. This study sought to explore the experiences of high school STEM teachers in Qatar, focusing on the pedagogical approaches they utilize and the challenges they encounter, with the aim of delving into how these approaches and barriers affect the teaching of STEM in the country's high schools. The study's design is observational, with data collected using a survey of 299 secondary high school STEM teachers (11th and 12th grades). To attain the goal of this study, we examined the barriers perceived to impede engagement in effective STEM teaching from high school teachers' perspective. The study's findings pointed to the influence of student- and school-related factors in shaping STEM teaching. Significant differences were detected based on teachers' gender, grade level of teaching, age group, and university education. Logistic regressions revealed that teachers' demographic attributes, including age group and university education, affect their likelihood to use STEM pedagogies in class. This likelihood was significantly affected by student-related barriers and the learning resources/materials employed in classrooms. These findings postulate critical evidence in directing the development of successful STEM learning practices within Qatar's high schools.

**Keywords:** STEM education; high school; teacher education; STEM pedagogies; barriers



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## 1. Introduction

In the face of the many global challenges the world is facing and the risks they pose to the future well-being of humanity, science, engineering, and technology are key to understanding and solving the pressing problems. Through advances in science, engineering, and technology, human beings can now find solutions to many of the urgent ills facing humanity, including climate change, health-related problems such as COVID-19, food shortages, overpopulation, resource management, and various other ailments. To deal with the complexities of modern society, which are mainly due to human activity, a new set of core skills and knowledge is needed. Herein lies the importance of science and technology as catalysts of prosperity and sustainable development for the present and future generations.

In the context of Qatar, in recent years, leadership has placed the importance of transforming the country from a hydrocarbon-based economy to a knowledge-based society high on its national agenda. At the heart of this plan is the demand for federal capacity building. Against this background, the need for professionals in science, technology, engineering, and mathematics (STEM) fields in Qatar is considered to be in crisis by various education, government, and industry circles [1,2]. While the demand for STEM professionals in Qatar is very high, the number of citizens with the education and training required for sustaining the industries vital to its economy remains alarmingly low. The mismatch between education and the job market needs in Qatar has resulted in a very high proportion of unskilled and semi-skilled citizens presently employed in the public sector [3]. Consequently, the private sector has had to rely on foreigners to fill the gap in STEM professions. With a significant deficit in the number of young people studying and contemplating a career in STEM, Qatar will continue to rely heavily on expatriate labor.

Compounding the problems associated with high levels of foreign labor in Qatar is that most young and highly educated Qatari citizens hold credentials in non-STEM fields. The private sector, dominated by industries, offers only a few positions suitable for young Qataris who attain university education in a non-STEM area [4]. Moreover, there is strong evidence that many Qataris, especially males, do not intend or desire to pursue tertiary education [5], a trend with severe ramifications for attempts to create a sustainable local STEM human capital in the country [6]. Indeed, there is a lack of documented research investigating how these problems linked with the shortage of skilled professionals in Qatar and the broader Gulf Cooperation Council (GCC) region can be addressed effectively.

While substantial gains have been made in terms of equitable access to formal education and enrolment and literacy rates in Qatar [6,7], many are critical of the inability of Qatar's education system to produce highly skilled graduates that can contribute to the nation's development, prosperity, and well-being [8,9]. Despite decades of steady gains, Qatari women's participation in the labor force is still meager. Declining female participation continues to affect growth and development in Qatar. Exacerbating the job market demographic imbalance is the significant dependency on highly skilled professionals from foreign countries, as was stated previously. To improve the capacity of its skilled workforce in the labor market, concerted efforts are required to increase the number of men and women enrolled in disciplines associated with the knowledge economy on a par with developing nations.

STEM education is essential to the economic development of Qatar. While the country's national development strategy highlights the importance of STEM education for progress and development, the practical application of STEM education continues to face many challenges, especially in developing countries, such as the GCC states. Therefore, this study aims to investigate teachers' perceptions regarding salient barriers to STEM education in high schools in Qatar. The originality of our research lies in offering insights into such barriers from an Arab Middle Eastern perspective.

This paper is structured as follows. Section 2 reviews the relevant literature on STEM, synthesizing and critically evaluating research dealing with critical challenges to STEM education. Section 4 describes in detail the research design and the methods employed in this current study, including the data collection and the type of analysis used. Section 5 provides a detailed description of the study's results, focusing on the different factors that shape teachers' perceptions of STEM education. Finally, Section 6 provides a discussion of these results.

## 2. Review of Literature

With the increasing demand for professionals who possess the skills and knowledge that are key to economic growth and development, the onus rests with educational institutions to prepare students equipped with critical STEM skill sets. To enhance students' STEM-related capabilities, schools in particular need to improve their STEM education offerings and redesign their instructional pedagogies [10]. Not surprisingly, the urgency of STEM for national progress, security, and well-being triggered the launch of a plethora of educational reforms that many countries worldwide embraced to revamp STEM education for the economy.

Hsu and Fang [11] identified two distinct approaches adopted in STEM education. One is both interdisciplinary and transdisciplinary and treats the contents of the different STEM disciplines as integrated and interrelated components. The other employs a multidisciplinary instructional approach that views STEM discipline contents as a cluster or constellation of individual STEM fields of study. In previous research, Gomez and Albrecht [12] suggested using an interdisciplinary approach that anchors STEM instruction and education in pedagogy to prepare students for STEM-related career pathways.

As key catalysts in the education process, teachers can have a critical role in teaching STEM, affect students' educational achievement in STEM subjects and ultimately influence their interest in STEM fields of study and careers [13]. Students learning and practical experiences are determinant factors that enhance their STEM skills and knowledge. Indeed, alongside these experiences, teachers and quality STEM programs create ideal opportunities for developing students' talents and abilities in STEM domains [14].

The extant literature refers to the interplay between a host of individual (personal), environmental (contextual), and behavioral factors that act as either enablers or barriers to STEM teaching. For example, Nugent and colleagues [15] suggested various social (contextual), motivational (interest and self-efficacy), and instructional (teachers and teaching) factors that create adequate conditions for effective STEM teaching. Other research conducted by Margot and Kettler's [10] systematic review of research exploring the teachers' perception regarding STEM education noted six key barriers that thwart STEM teaching. These challenges are associated with the curriculum, pedagogy, assessment, teacher support, students, and structural systems.

Current debates on STEM education point to hindrances that impede the implementation of effective interdisciplinary modes of teaching STEM. Examples reported in the literature include teachers' beliefs, knowledge, and understanding of STEM [16,17]. Other examples include poor teacher preparation, lack of professional development for teachers, shortage of teachers, poor cross-disciplinary content integration, low student motivation, inadequate facilities, and inappropriate assessments [11,18]. Work by Wahono and Chang [19] indicated three main barriers facing STEM teachers: insufficient knowledge, difficulty applying STEM to some topic areas, and difficulty linking the different STEM topics.

For the purpose of this study, two main theoretical models provided a framework for our research: Bandura's social cognitive theory (1986) and Attribution Theory [20,21]. First, the social cognitive theory (SCT) is used as a theoretical lens that lends a rationale for considering individual and environmental (contextual or school-related) factors. This theoretical lens proved helpful in examining individual characteristics, including self-efficacy, a concept central to SCT [22]. Past research revealed the importance of self-confidence in classroom instruction and the teaching of science subjects [23,24]. Second, the attribution theory (AT), a well-known research paradigm in social psychology, helps to understand why a particular behavior or event occurs and attributes the specific causes to the occurrence. In other words, the AT serves to make sense of the social world and explain how individuals perceive the causes of daily life experiences. Therefore, based on the literature, this study hypothesized that high school STEM teachers face challenges in Qatar that affect their teaching process.

## 3. Research Questions

This study aims to address the following research questions:

1. What are the barriers identified by teachers as impeding STEM teaching in their classrooms?
2. What are the factors likely to influence teachers' use of STEM pedagogical approaches in their teaching?
3. Are there any significant differences pertaining to these barriers based on demographics, such as teachers' gender, age group, geographic location of the university they graduated from, and grade level of teaching?

## 4. Methods

Our study's design is observational, with data obtained using survey questionnaires to explore the experiences of high school STEM teachers in Qatar regarding the pedagogical approaches they use and the challenges they encounter. In so doing, the aim was to dig into the way these approaches and challenges affect the teaching of STEM subjects in Qatar's high schools. A cross-sectional survey was created based on two components: STEM teaching approaches and barriers to effective STEM teaching. To collect the data required for this research, a survey was administered physically and virtually over two months during the 2021 Spring Semester (March–April 2021). The survey was first administered using paper questionnaires (paper-and-pencil interviewing–PAPI). However, the response rate was low, and the researchers decided to also gather data using computer-assisted personal interviewing (CAPI).

### *4.1. Participants*

The study was carried out in thirty-nine high schools across Qatar. These schools were randomly selected from local government schools (56.4%) and private schools (43.6%) in Qatar. Upon receiving approval from Qatar University's research ethics board (IRB), school board superintendents and teachers were contacted to allow the researchers to collect teacher data in their schools. With the exclusion of teachers who did not complete the entire survey, a total of 299 teachers participated in the study.

Table 1 illustrates teachers' demographic distribution, demonstrating their distribution by gender (54.5% males and 45.5% females) and age group, ranging from 31 to 40 (40.1%). More than half of the participants held a bachelor's degree (59.5%) and many more reported graduating from an Arab university outside Qatar (64.9%). Almost all were expatriates (96%). Although the bulk of teachers taught both grades 11 and 12 (45.8%), 25.8% taught grade 11, and 24.7% taught grade 12 exclusively. Science teachers made up the majority of respondents (45.8%), followed by mathematics teachers (30.1%), followed by engineering and technology teachers (8.7%). The remaining 15.38% taught multiple subjects (at least one STEM subject). Most teachers reported teaching between 11 and 20 h per week (65.6%).

**Table 1.** Teacher demographics (N = 299).

| Variable | Sub-Categories | Percentage | N |
|---|---|---|---|
| Gender | Male | 54.5 | 163 |
| | Female | 45.5 | 136 |
| Age Group | 30 or less | 8.7 | 26 |
| | 31 to 40 | 40.1 | 120 |
| | 41 to 50 | 33.8 | 101 |
| | 51 or more | 16.7 | 50 |
| Nationality | Qatari | 1.7 | 5 |
| | Non-Qatari | 96.0 | 287 |
| Educational Qualification | Diploma | 4.0 | 12 |
| | B. A. degree | 59.5 | 178 |
| | Master's degree | 32.8 | 98 |
| | Doctorate/Ph.D. | 2.7 | 8 |
| Type of University | A University or College in Qatar | 6.4 | 19 |
| | An Arab University outside Qatar | 64.9 | 194 |
| | An American or European University outside Qatar | 10.7 | 32 |
| | An Asian or African University outside Qatar | 17.4 | 52 |
| Experience in Qatar | Less than one year | 2.7 | 8 |
| | More than one year to two years | 10.4 | 31 |
| | More than two years to five years | 15.7 | 47 |
| | More than five years to ten years | 35.5 | 106 |
| | More than ten years to twenty years | 28.1 | 84 |
| | More than twenty years | 6.7 | 20 |

**Table 1.** *Cont.*

| Variable | Sub-Categories | Percentage | N |
|---|---|---|---|
| Grade level of Teaching | Grade 11 | 25.8 | 77 |
| | Grade 12 | 24.7 | 74 |
| | Both Grades 11 and 12 | 45.8 | 137 |
| Class size | 10 or less | 3.7 | 11 |
| | 11 to 20 | 34.1 | 102 |
| | 21 to 30 | 44.1 | 132 |
| | 31 or more | 15.4 | 46 |
| Teaching subject | Science | 45.8 | 137 |
| | Technology and Engineering | 8.7 | 26 |
| | Mathematics | 30.1 | 90 |
| | Multiple subjects | 15.3 | 46 |
| Teaching Hours in a week | 10 or fewer hours per week | 11.7 | 35 |
| | 11 to 20 h per week | 65.6 | 196 |
| | 21 to 30 h per week | 20.1 | 60 |
| | 31 h or more per week | 1.0 | 3 |

### *4.2. Survey Instrument*

The execution process consisted of three phases: (1) survey formulation, (2) survey piloting, and (3) survey execution.

Step 1: To develop the survey, we examined existing research on (a) STEM teaching [25–31]); (b) the role of teachers in STEM (e.g., [10,32–36]); (c) successful pedagogical approaches in STEM education (e.g., [37–40]; and (d) barriers to STEM teaching (e.g., [18,41–43]. Reviewing this literature allowed us to grasp the survey's target areas better and helped us understand general perceptions of STEM teaching as perceived by teachers and students, thus enabling us to develop items addressing the barriers and challenges teachers face when teaching STEM. A five-point Likert scale was used to grade 110 closed objects within five constructs as follows: Student-related barriers faced in teaching STEM, School-related barriers faced in teaching STEM, STEM-related pedagogical approaches, STEM-related teaching activities, and Factors affecting the decline of student interest in STEM. For each survey construct, teachers were given different response options depending on the type of question. These types included disagree-agree questions (strongly disagree = 1; disagree = 2; slightly disagree = 3; slightly agree = 4; agree = 5; and strongly agree = 6), frequency questions (never = 1; rarely = 2; sometimes = 3; often = 4; always = 5), percentage questions, rating questions (very poor = 1; poor = 2; fair = 3; good = 4; very good = 5), emphasis questions (none= 1; minimal = 2; moderate = 3; considerable = 4; heavy = 5), and importance questions (not important at all = 1; not important = 2; undecided = 3; important = 4; very important = 5).

Step 2: This step included testing the developed survey with two focus groups, one in Arabic and the other in English, to fine-tune the instrument. The focus group discussions aided us in addressing concerns we had regarding the wording of questions. This helped in rewriting and clarifying inadequately worded questions. The survey's primary goals were to collect (a) basic background knowledge, (b) systematic evidence of teaching approaches, and (c) structured evidence of the main challenges to effective STEM teaching.

Step 3: The questionnaires were distributed after receiving all signed consent papers from teachers and school authorities. Teachers were instructed to respond to the survey in English or Arabic. The average time it took for the participants to complete the study was between 13 and 17 min. Factor analysis was used to form constructs which measured important factors that would help answer the RQs of this study. This was performed using a principal component analysis and varimax rotation with a minimum factor loading criteria of 0.50. To guarantee adequate levels of explanation, the communality of the scale, which depicts the degree of variation in each component was evaluated. The findings indicate that all communalities were more than 0.50. The significance of the data, ($\chi^2$ (820) = 6096.87, $p < 0.010$), indicated that factor analysis was appropriate. The Kaiser–Mayer–Olkin (KMO) and Bartlett's test of sphericity were used to confirm the sampling adequacy. The data was found to be suitable for factor analysis according to the KMO value which was 0.885. Results of the factor analysis are shown in Table 2.

**Table 2.** Factor loadings for the items in each construct.

| Items | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Student-related Teaching Barriers** | | | | | |
| STB1 | 0.797 | | | | |
| STB2 | 0.827 | | | | |
| STB3 | 0.782 | | | | |
| STB4 | 0.616 | | | | |
| STB5 | 0.731 | | | | |
| **School-related Teaching Barriers** | | | | | |
| SCTB1 | | 0.578 | | | |
| SCTB2 | | 0.625 | | | |
| SCTB3 | | 0.802 | | | |
| SCTB4 | | 0.852 | | | |
| SCTB5 | | 0.791 | | | |
| SCTB6 | | 0.692 | | | |
| SCTB7 | | 0.703 | | | |
| SCTB8 | | 0.621 | | | |
| SCTB9 | | 0.617 | | | |
| SCTB10 | | 0.697 | | | |
| SCTB11 | | 0.849 | | | |
| SCTB12 | | 0.877 | | | |
| SCTB13 | | 0.571 | | | |
| SCTB14 | | 0.599 | | | |
| SCTB15 | | 0.737 | | | |
| SCTB16 | | 0.794 | | | |
| SCTB17 | | 0.654 | | | |
| SCTB18 | | 0.715 | | | |
| **Teacher Pedagogical Approach** | | | | | |
| TP1 | | | 0.637 | | |
| TP2 | | | 0.772 | | |
| TP3 | | | 0.696 | | |
| TP4 | | | 0.682 | | |
| TP5 | | | 0.756 | | |
| TP6 | | | 0.828 | | |
| TP7 | | | 0.771 | | |
| **Teaching Activity** | | | | | |
| TA1 | | | | 0.678 | |
| TA2 | | | | 0.737 | |
| TA3 | | | | 0.751 | |
| TA4 | | | | 0.744 | |
| TA5 | | | | 0.728 | |
| TA6 | | | | 0.727 | |
| **Decline in Student's Interests** | | | | | |
| DSI1 | | | | | 0.660 |
| DSI2 | | | | | 0.675 |
| DSI3 | | | | | 0.661 |
| DSI4 | | | | | 0.797 |
| DSI5 | | | | | 0.655 |

Further, Cronbach alpha ($\alpha$) was used to assess the internal consistency of the reliability. The computed values of $\alpha$ for each survey construct are given in Table 3. According to researchers [44], alpha levels above 0.70 are regarded as reliable, whereas values greater than 0.90 are considered extremely reliable. The estimated alphas in this study revealed a reliable and very highly reliable scale.

**Table 3.** Cronbach's Alpha values for constructs in the teacher questionnaire (with examples of survey items).

| Construct | No. of Items | Cronbach Alpha |
|---|---|---|
| Student-related barriers faced in teaching STEM<br>*To what extent is your teaching affected by students' lack of interest? (Frequency choice)* | 5 | 0.832 |
| School-related barriers faced in teaching STEM<br>*To what extent is your teaching affected by insufficient pedagogical support for teachers? (Frequency choice)* | 24 | 0.967 |
| Teacher's approach to STEM pedagogies<br>*To what extent do you apply inquiry-based education? (Frequency choice)* | 9 | 0.854 |
| Teacher's STEM-related teaching activity<br>*How often do you make students work in cooperative learning groups? (Frequency choice)* | 12 | 0.824 |
| Factors affecting the decline of student interests<br>*How often do traditional methods of instruction encouraging rote memorization contribute to the decline of students' interest in your class? (Frequency choice)* | 6 | 0.823 |

### *4.3. Data Analysis*

#### 4.3.1. Measures

The survey constructs were formulated as quantitative measures to represent important factors that would help answer the RQs of this study. These measures included student-related teaching barriers, school-related teaching barriers, teacher pedagogy, teacher activity, and a decline in student interests. The reason for the selection of these measures was because previous analyses revealed that though instructors favor STEM teaching, many instructional impediments hinder effective STEM teaching, including the curriculum, structural problems, concerns with students and evaluations, and a lack of teacher support [10,45]. Moreover, there is evidence that suggests that high-quality teachers significantly impact students' perceptions of STEM and, in many circumstances, student achievement [46]. Therefore, we consolidated our survey items into five measures to singularly represent the items they contain. For this, Likert-scaled survey items under each construct were coded into numbers, and then summed to obtain an overall score for the respective construct. Since Likert-type data are ordinal and only account for one score being higher than the other, and not the distance between the points, some of the measures required to be coded into dichotomous variables to represent the data as nominal categories (as explained below for each measure). These measures have already been validated in Section 4.2. Below are the details of the formulation of these measures.

Student-Related Teaching Barrier Score

The first measure used in this analysis is a student-related teaching barrier (STB) score. Teachers were asked to define the extent to which their teaching was affected due to various student-related issues. These issues comprised of the following: lack of required skills, lack of necessary knowledge, not having enough sleep, disruption in the classroom, and lack of interest. Teachers' answers on their perceptions of students were encrypted to dichotomous variables by allocating a score of "1" to responses that corresponded to "often" and "always" and a value of "0" to those with "never", "rarely" or "undecided". These five statements were then tallied to get a single STB score ranging from 0 to 5. This score indicated the collective magnitude of challenges teachers faced in their STEM teaching due to student-related issues.

School-Related Teaching Barrier Score

The second measure used in this analysis is a school-related teaching barrier (SCTB) score. Teachers were asked to define the extent to which their teaching was affected due to various school-related issues. These issues comprised of the following: technical support, STEM training and pedagogical support, curriculum and teaching hours, instructional materials and supplies, classroom adequacy, outdated school computers, school space organization, administrative and budget constraints, school environment, and support and interest from fellow teachers. Teachers' responses to these questions were encoded into dichotomous variables by giving "1" to responses that matched with "often" and "always" and a "0" to those which matched with "never," "rarely," or "undecided". These five statements were then added to get a single SCTB score ranging from 0 to 18. This score reflected the cumulative extent to which teachers faced challenges in their STEM teaching due to school-related issues.

Teacher Pedagogical Score

The third measure used in this analysis is a teacher pedagogical (TP) score. Teachers were asked to define the extent to which they used various pedagogical approaches on a scale ranging from (1) 0–20% to (5) 81–100%. These approaches comprised of the following: project/problem-based approaches, collaborative learning, peer teaching, flipped classroom, personalized teaching, integrated learning, and differentiated instruction. Teachers' responses were then encoded into numerical variables by allocating values from 1 to 5 to the range of percentages. Therefore, 0–20% was coded as 1, 21–40% as 2, 41–60% as 3, 61–80% as 4, and 81–100% as 5. Additionally, the scores of all the different pedagogies were summed to obtain a single TP score ranging from 1 to 35. This score reflected the extent to which teachers applied pedagogical approaches in STEM. The TP score was then used to formulate the likelihood of teachers using pedagogical approaches in STEM teaching. This was done by translating the TP score to dichotomies for use in the logistic regression model on the basis that the extent of using pedagogical approaches by teachers in classrooms should at least correspond to 50%. Therefore, an average score of 2.5 for the seven items pertaining to TP score could be considered as teachers having a high likelihood to use pedagogical approaches in STEM teaching. Hence, teachers with high TP scores greater than 18 out of 35 were coded as "1" and teachers with low TP scores below 23 were recorded as "0".

Teacher Activity Score

The fourth measure used in this analysis is a teacher activity (TA) score. Teachers were asked to define the extent to which they implemented activities beneficial for STEM teaching. This included their use of different type of materials (audio, visual, written), engaging students in group discussions, making students see connections between different disciplines, helping them consider alternative explanations, and encouraging students to provide explanations. Teachers' responses to these activities were then coded into numerical equivalents by giving a score of "1" to responses that matched with "often" and "always" and "0" to those which matched with "never," "rarely," or "undecided". Furthermore, the scores were summed to obtain a single TA score ranging from 1 to 6. This score showed the overall degree to which teachers used activities beneficial for STEM learning.

Decline in Student Interest Score

The fifth measure used in this analysis is a decline in student interest (DSI) score. Teachers were asked to define the extent various student-related factors contributed to the decline of students' STEM interests in the class. These factors comprised of the following: lack of confidence, negative perceptions of STEM-related careers, lack of parental and family involvement, facing difficulty in homework, and lack of use (or misuse of) technology. Teachers' responses to these various activities were then coded into numerical equivalents by allocating a score of "1" to responses that corresponded to "often" and "always" and a value of "0" to those with "never", "rarely" or "undecided". Further, the scores of all the different activities were summed to obtain a single DSI score ranging from 1 to 5. This score reflected how various student-related factors contributed to declining students' STEM interests.

#### 4.3.2. Statistical Analysis

SPSS (Version 29) was used to analyze all the data. Descriptive statistics were used to show the distribution of the demographics of the teachers. Graphical scales were developed to represent the distribution of the measures formulated in Section 4.3.1. These measures were analyzed using means and percentages to answer the RQ1. Further, bivariate logistic regression models were built to analyze the RQ2 which included interval and ratio-scaled variables. Using this, the relative effect of various factors on the likelihood of teachers employing STEM pedagogies was investigated. These factors included teachers' school-related barriers, teaching activities, age group, university education, and teachers' use of resources and materials. Furthermore, teachers' use of various resources and materials on their likelihood to employ pedagogical practices in STEM teaching was also regressed. Lastly, various non-parametric tests were chosen to answer the RQ3 depending on the statistical measurement and distributions [47,48]. Non-parametric analyses were used to compare differences between teacher's demographical groups. In the case of two groups (gender, grade level of teaching) the Mann–Whitney U test was used to evaluate significant differences. The Kruskal–Wallis H test was used to explore significant differences between three or more groups (age group, geographic location of graduation university of teachers). If the Kruskal–Wallis test yielded statistically significant findings, Dunn's test was used to compare each independent group pairwise and check whether groups are statistically significant at some threshold. In addition, since the given value of significance may be appropriate for individual comparisons and not for the set of all comparisons, the Bonferroni correction was employed when performing the Kruskal–Wallis test.

## 5. Results

### *5.1. Teachers' Perceptions of STEM Teaching*

The perceptions of teachers were evaluated using specified measures, as stated in Section 4.3.1. The results of these measures are discussed below.

#### 5.1.1. Student-Related Teaching Barrier Score

Teachers were asked to rate the extent to which they faced student-related barriers. This was done by asking teachers if their teaching was affected by various student-related issues. These responses were summarized to achieve an overall STB score. The STB score ranged from a scale of 0 to 5, with 5 denoting a high degree of teaching barrier due to student-related factors. Figure 1 shows the distribution of the STB score.

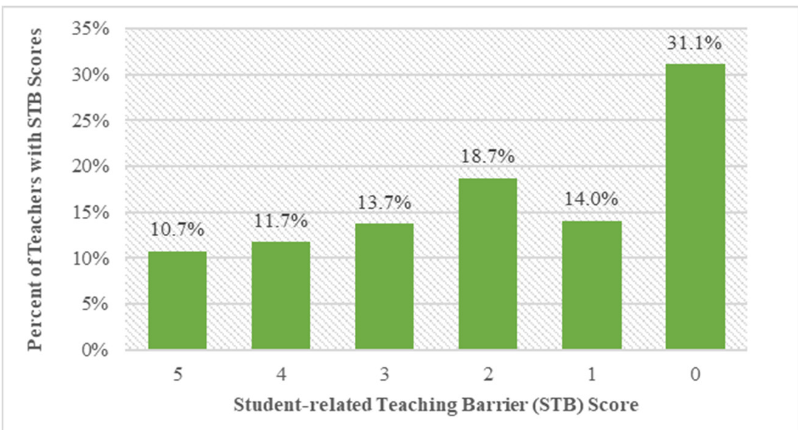


**Figure 1.** Student-related Teaching Barrier (STB) Scale.

The mean STB score was 1.93 (SD 1.72), indicating that there was no serious concern in the combined student-related barriers faced by teachers on an overall level. However, for further investigation into each student-related barrier individually, the teachers' responses were coded into two groups, having an extreme or high effect or low or no effect. The results are portrayed in Table 4. It was observed that almost half of the teachers were highly affected by students lacking the required skills (48.95%) and students not having enough sleep (48.09%). Moreover, 46% of the teachers reported that students lacked the necessary knowledge, which affected their teaching. Students' lack of interest and disruption in the classroom were reported to have an extreme or high effect on instruction by a lesser proportion of teachers, 36.11% and 22%, respectively. Therefore, these results indicate that, though teachers generally do not face student-related barriers on a macro scale, students' lack of skills, knowledge, and sleep significantly impacts STEM teaching in Qatar.

**Table 4.** Student-related barriers which affect STEM teaching in Qatar.

| Student-Related Barrier | To What Extent Is Your Teaching Affected by the Following? (N = 299) | |
|---|---|---|
| | Extreme or High Effect (%) | Low or No Effect (%) |
| Students lacking the required skills | 49.00 | 51.00 |
| Students did not have enough sleep | 48.10 | 51.90 |
| Students lacking the required knowledge | 46.00 | 54.00 |
| Students' lack of interest | 36.10 | 63.90 |
| Students' disruption in the classroom | 22.00 | 78.00 |

### 5.1.2. School-Related Teaching Barrier Score

Teachers were asked to rate how much they struggled with school-related issues. This was accomplished by asking teachers if school-related specific problems had an impact on their teaching. To get an overall SCTB score, the replies were added together. The SCTB score varied from 0 to 18, with a score of 18 indicating a significant teaching barrier due to student-related variables. Figure 2 shows the distribution of the SCTB score.

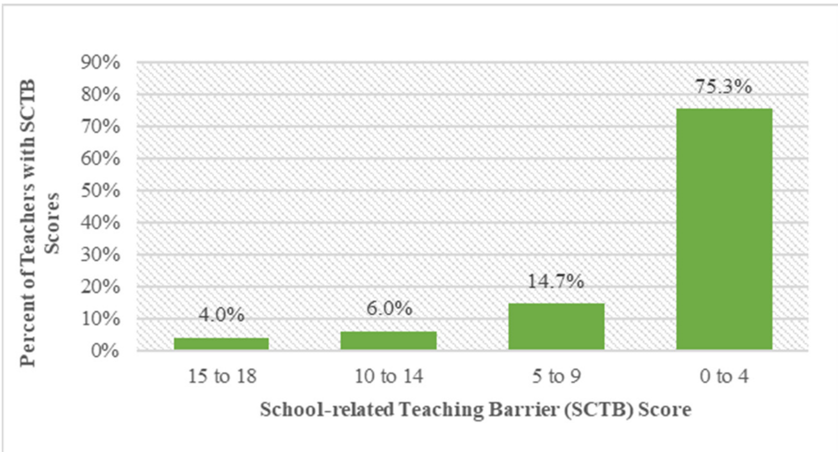


**Figure 2.** School-related Teaching Barrier (SCTB) Scale.

The mean SCTB score was 3.09 (SD 4.41), indicating that overall, student-related barriers faced by teachers were low. However, for further research into each student-related barrier separately, teachers' responses were divided into two groups with an extreme or high effect or low or no effect, as shown in Table 5.

**Table 5.** School-related barriers which affect STEM teaching in Qatar.

| School-Related Barrier | To What Extent Is Your Teaching Affected by the Following? (N = 299) | |
|---|---|---|
| | Extreme or High Effect (%) | Low or No Effect (%) |
| Teachers have too many teaching hours | 33.30 | 66.70 |
| School computers out of date and/or needing repair | 23.00 | 77.20 |
| Classrooms are overcrowded | 21.50 | 78.50 |
| Administrative constraints in accessing adequate content/material for teaching | 20.20 | 79.90 |
| Teachers do not have adequate instructional supplies | 19.20 | 80.70 |
| Implementing the school's curriculum | 18.60 | 81.30 |
| Teachers do not have adequate instructional materials | 18.60 | 81.40 |
| School space organization (classroom size, furniture, etc.) | 18.60 | 81.40 |
| The school environment | 18.10 | 81.80 |
| Lack of pedagogical models on how to teach STEM | 16.80 | 83.20 |
| Understanding the curriculum | 16.60 | 83.40 |
| Lack of adequate training of teachers | 16.30 | 83.60 |
| Budget constraints in accessing adequate content/material for teaching | 16.10 | 83.90 |
| Insufficient technical support for teachers | 16.00 | 83.90 |
| Insufficient pedagogical support for teachers | 15.10 | 85.00 |
| Insufficient support from colleagues | 13.20 | 86.80 |
| Teachers' lack of interest | 12.20 | 87.80 |
| Lack of content in national language | 9.40 | 90.50 |

#### 5.1.3. Teacher Pedagogical Score

Teachers were asked to rate the extent to which they employed different pedagogical practices in their STEM teaching. Teacher's responses were combined to produce an overall TP score. The TP score ranged from 0 to 35, with the latter denoting a high use of STEM pedagogical approaches. Figure 3 shows the distribution of the TP score.

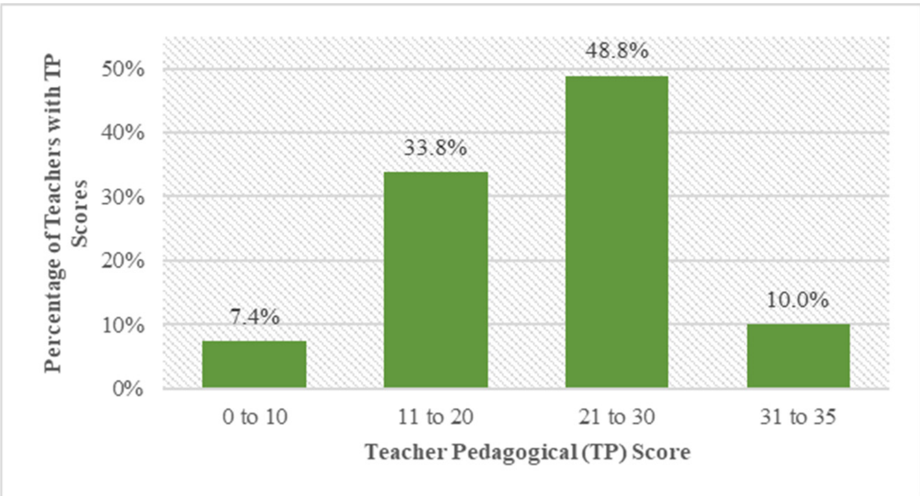


**Figure 3.** Teacher Pedagogical Score (TP) Scale.

The mean TP score was 21.45 (SD 6.88), indicating that overall, teachers employed pedagogical approaches to a reasonable extent. However, for the examination of each pedagogical approach individually, teachers' responses were divided into two groups having a high extent or low extent, as shown in Table 6.

**Table 6.** Pedagogical Approaches used in STEM teaching in Qatar.

| Pedagogical Approaches | To What Extent Do You Apply the Following Pedagogical Approaches in Your Teaching? (N = 299) | |
|---|---|---|
| | High Extent (%) | Low Extent (%) |
| Collaborative learning | 56.70 | 43.30 |
| Integrated learning | 51.90 | 48.10 |
| Differentiated instruction | 46.20 | 53.80 |
| Project-/Problem-based approach | 45.00 | 55.00 |
| Peer teaching | 44.80 | 55.30 |
| Personalized learning | 44.30 | 55.80 |
| Flipped classroom | 20.60 | 79.50 |

5.1.4. Teacher Activity Score

Teachers were asked to rate how often they used various teaching activities in their STEM instruction. Teacher's responses to these items were added together to generate a total TA score. The TA score varied from 0 to 6, with a score of 6 indicating extensive usage of activities in the classroom. Figure 4 shows the distribution of the TA score.

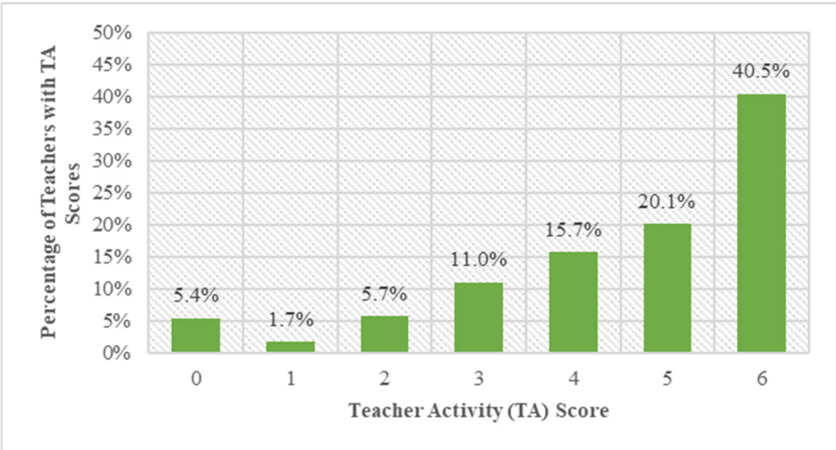


**Figure 4.** Teacher Activity Score (TA) Scale.

The mean TA score was 4.53 (SD 1.68), implying that on the overall level teacher's use of activities in their teaching was considerably high. For further research into each teaching activity, teachers' responses were divided into two groups having a high or low extent, as shown in Table 7.

**Table 7.** Teaching Activities used in STEM teaching in Qatar.

| Teaching Activities | To What Extent Do You Implement the Following in Your Teaching? (N = 299) | |
|---|---|---|
| | High Extent (%) | Low Extent (%) |
| Engage the whole class in discussions | 89.60 | 10.30 |
| Use different type of materials (audio, visual, written) | 87.30 | 12.60 |
| Do group discussions with students | 80.30 | 19.80 |
| Help students see connections between different disciplines | 79.80 | 20.30 |
| Ask students to consider alternative explanations | 67.00 | 33.10 |
| Require students to supply evidence to support their claims | 66.10 | 33.90 |

5.1.5. Decline in Student Interest Score

Teachers were asked to rate how various student-related factors contributed to the decline of students' STEM interests in class. The responses were totaled to arrive at a total

DSI score. The DSI score ranged from 0 to 5, with a 5 signifying a high decline in student interests. Figure 5 shows the distribution of the DSI score.

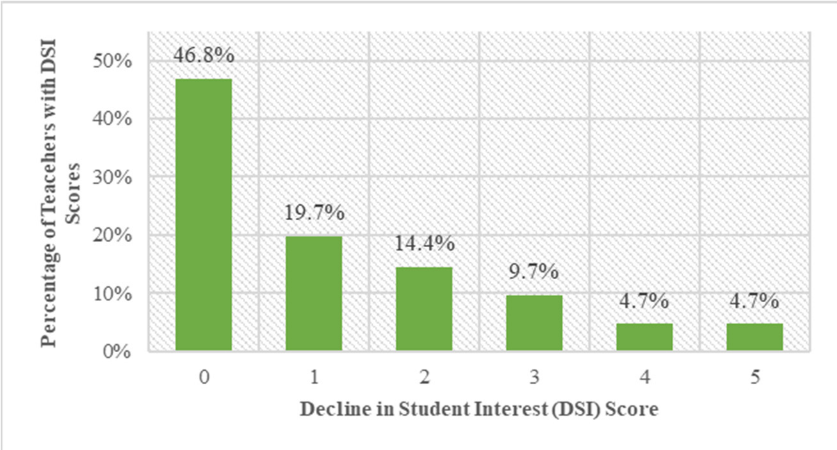


**Figure 5.** Decline in Student Interest (DSI) Scale.

The mean DSI score was determined to be 1.19 (SD 1.46), implying that the overall decline in students' interests due to student-related factors was not very concerning. However, for further investigation into each factor, teachers' responses were coded into two groups: either extreme or high effect or low or no effect. The results are portrayed in Table 8. It was observed that more than one-third of the teachers described a lack of parental and family involvement as a major factor in students' decline in STEM interests.

**Table 8.** Teachers' perception of the extent to which student-related barriers cause the decline in students' interest.

| Student-Related Barrier | How Often Do the Following Factors Contribute to Declining Students' Interest in Your Class? (N = 299) | |
|---|---|---|
| | Extreme or High Effect (%) | Low or No Effect (%) |
| Lack of parental and family involvement | 35.67 | 64.33 |
| Lack of confidence | 30.29 | 69.71 |
| A negative perception of STEM-related careers | 23.42 | 76.57 |
| Lack of use (or misuse of) technology | 22.10 | 77.89 |
| Difficulty of homework | 13.93 | 86.06 |

### *5.2. Factors Likely to Influence Teachers' Use of STEM Pedagogical Approaches*

Regression analyses were performed to assess the parameters that affected teachers' perception of STEM teaching. Several bivariate regression models were built to predict teachers' likelihood to employ pedagogical approaches in their STEM teaching in connection with other measures and demographic factors.

#### 5.2.1. Teacher's Student-Related Barriers, Teaching Activity, Age Group, and University of Graduation on Their Likelihood to Use STEM Pedagogical Approaches

A bivariate logistic regression model was built to ascertain whether factors are associated with the likelihood of teachers employing STEM pedagogical practices in their classrooms. These factors include STB score, TA score, nationality (Qatari or non-Qatari), age group, and graduated university. For this, the dependent variable was chosen to be the TP score, which was coded into dichotomies (TP score greater than 23 as "1" and TP score less than 23 as "0") to fit the regression model. The proposed regression model pointed to the chances of employing more pedagogical practices in STEM teaching (ODDS) = *f*(STB score, TA score, nationality, age group, and university level). Upon examination of comparing a complete regression model to an intercept-only model, the analysis was statistically significant ($\chi^2$ (9) = 33.434, $p < 0.001$). The regression explained 15.5% of the variation of teachers who were likely to employ STEM pedagogies and correctly predicted 74.8% of all the cases. The regression also uncovered that teachers with high STB scores were marginally less likely to use STEM pedagogies than teachers with low STB scores (probability = 0.54).

Moreover, teachers with high TA scores were 1.3 times more likely to use pedagogical approaches in STEM teaching than those with low TA scores (probability = 0.58). Additionally, the age group of teachers was a statistically significant predictor of the likelihood of using pedagogical approaches in STEM teaching. Teachers younger than 50 were 2.182 times (on average) more likely to use pedagogical practices in their STEM teaching compared to those above 50 years of age (probability 0.68). Another interesting finding that the regression revealed was that the region of the university that teachers graduated from significantly affected their likelihood of employing pedagogical approaches in STEM teaching. Teachers from an American or European university were 6.07 times more likely to use pedagogical approaches in STEM teaching compared to teachers from Asian or African universities (probability = 0.86). Corroborating this, teachers from Arab universities were 1.896 times (on average) more likely to use pedagogical approaches in STEM teaching compared to teachers from Asian/African universities (probability = 0.65). Lastly, nationality was not statistically significant predictor of the likelihood of using pedagogical approaches in STEM teaching.

In summary, the results of this logistic regression showed that student-related teaching barriers faced by STEM teachers in Qatari schools significantly decrease their likelihood of using STEM pedagogies. Meanwhile, using STEM teaching activities in classrooms is a substantial factor in increasing the possibility of employing STEM teaching approaches. Further, their age group and university education were the main predictors of teachers' likelihood to use STEM pedagogies. While teachers under 50 were more likely to use STEM pedagogies, teachers from American or European universities were highly likely (probability almost 1) to use STEM pedagogical approaches. It should be noted that while the age group was found to be a significant predictor, teaching experience was not. Further, while university location significantly affected the likelihood of using STEM instructional approaches, nationality (Qatari/Non-Qatari) did not. The results are summarized in Table 9.

**Table 9.** Bivariate logistic regression of the relationship between STB score, TA score, nationality, age group, and university level on teacher's likelihood to employ pedagogical approaches in STEM teaching.

| Variable | B | Wald $\chi^2$ | Sig. | Exp(B) (ODDS) | Probability |
|---|---|---|---|---|---|
| STB Score | −0.165 | 3.959 | 0.047 | 0.848 | 0.46 |
| TA Score | 0.314 | 14.161 | 0.000 | 1.370 | 0.58 |
| Nationality | −1.409 | 1.383 | 0.240 | 0.244 | 0.20 |
| Age Group | - | 7.873 | 0.049 | - | - |
| Age Group (30 or less) | 0.579 | 1.140 | 0.286 | 1.783 | 0.64 |
| Age Group (31 to 40) | 1.087 | 7.794 | 0.005 | 2.964 | 0.75 |
| Age Group (41 to 50) | 0.588 | 2.380 | 0.123 | 1.800 | 0.64 |
| University Level | - | 8.410 | 0.038 | - | - |
| University Level (University inside Qatar) | 0.765 | 2.048 | 0.152 | 2.148 | 0.68 |
| University Level (University outside Qatar) | 0.497 | 0.600 | 0.439 | 1.643 | 0.62 |
| University Level (American/European University) | 1.805 | 7.192 | 0.007 | 6.079 | 0.86 |
| Constant | −0.260 | 0.039 | 0.844 | 0.771 | - |

#### 5.2.2. Teacher's Use of Resources and Materials on Their Likelihood to Employ Pedagogical Practices in STEM Teaching

A second bivariate logistic regression model was built to determine whether or not teachers' use of teaching resources correlated with their likelihood of employing STEM pedagogical practices in classrooms. Eleven teaching resources were explored in the regression. The hypothesized regression model was the likelihood of using more pedagogical practices in STEM teaching (ODDS) = $f$(paper-based materials, audio or video materials, presentations, robots, calculators, graphing calculators, computer-based simulations, STEM-specific software, data sets or spreadsheets, word processors, and online tools). A test of the full regression model compared to an intercept-only model was statistically significant ($\chi^2$ (11) = 24.671, $p$ = 0.010). The regression explained 11.3% of the variation of those likely to employ STEM pedagogies and correctly predicted 70.8% of all the cases. The analysis revealed that teachers who used online tools as a resource for their teaching were 2.4 times more likely to employ STEM pedagogies (probability = 0.71). Moreover, teachers who used conventional calculators (not graphing) when teaching their courses were statistically less likely to employ STEM pedagogies than the teachers who did not use traditional calculators (probability = 0.35). The remaining resources and materials were not statistically significant predictors of the likelihood of employing pedagogical approaches for STEM teaching.

These results reveal that online tools significantly affect the likelihood of teachers to use STEM pedagogical approaches in their teaching. Another interesting finding was that using traditional resources such as calculators decreased the possibility of teachers employing pedagogical techniques in their STEM teaching. This shows that online tools are more adaptable for teachers when using STEM pedagogical approaches. Further, from the other resources that were not statistically significant in the regression, one essential resource was the use of STEM-specific software. This is worrying as using STEM-specific software ideally should positively affect teachers' likelihood of using STEM pedagogies. The results are summarized in Table 10.

**Table 10.** Bivariate logistic regression of the relationship teaching resources and materials on teacher's likelihood to employ pedagogical approaches in STEM teaching.

| Variable | B | Wald $\chi^2$ | Sig. | Exp(B) (ODDS) | Probability |
|---|---|---|---|---|---|
| Paper-based materials | 0.225 | 0.540 | 0.462 | 1.252 | 0.56 |
| Audio/video materials | 0.115 | 0.086 | 0.770 | 1.122 | 0.53 |
| Presentations | 0.235 | 0.200 | 0.655 | 1.265 | 0.56 |
| Robots | −0.515 | 1.064 | 0.302 | 0.597 | 0.37 |
| Calculators | −0.639 | 4.424 | 0.035 | 0.528 | 0.35 |
| Graphing calculators | 0.596 | 2.996 | 0.083 | 1.815 | 0.64 |
| Computer-based simulations | −0.117 | 0.170 | 0.680 | 0.889 | 0.47 |
| STEM-specific software | −0.317 | 1.110 | 0.292 | 0.728 | 0.42 |
| Data sets/spreadsheets | −0.588 | 3.776 | 0.052 | 0.556 | 0.36 |
| Word processors | 0.051 | 0.019 | 0.890 | 1.053 | 0.51 |
| Online tools | 0.882 | 10.095 | 0.001 | 2.417 | 0.71 |
| Constant | 0.616 | 1.431 | 0.232 | 1.851 | - |

A third bivariate logistic regression model was developed to determine whether teachers' use of learning resources for teaching challenging concepts correlated with their likelihood of having high teaching activity in classrooms. Four teaching resources were explored in the regression. The hypothesized regression model was the likelihood of using more pedagogical practices in STEM teaching (ODDS) = $f$(colleagues, educational and research journals, online resources, secondary textbooks). A test of the full regression model compared to an intercept-only model was statistically significant ($\chi^2$ (4) = 17.477, $p$ = 0.002). The regression explained 8.6% of the variation of teachers who were likely to employ STEM pedagogies and correctly predicted 77.5% of all the cases. The analysis revealed that teachers who used educational and research journals for teaching challenging concepts were 2.4 times more likely have a high teaching activity (probability = 0.71). Moreover, the use of online resources to teach challenging concepts showed a 2.1 times higher likelihood of having high teaching activity (probability = 0.68). The remaining resources and materials were not statistically significant predictors of teachers' likelihood of using pedagogical approaches for STEM teaching. These results indicate that using educational and research journals and online resources for teaching challenging concepts dramatically affects the likelihood of teachers to have a high teaching activity. The results are summarized in Table 11.

**Table 11.** Bivariate logistic regression of the relationship between the use of resources for teaching challenging concepts on teachers likelihood to have a high teaching activity.

| Variable | B | Wald $\chi^2$ | Sig. | Exp(B) (ODDS) | Probability |
|---|---|---|---|---|---|
| Secondary textbooks | 0.441 | 2.399 | 0.121 | 1.555 | 0.61 |
| Colleagues | 0.253 | 0.800 | 0.371 | 1.288 | 0.56 |
| Education and research journals | 0.878 | 7.090 | 0.008 | 2.405 | 0.71 |
| Online resources | 0.767 | 6.285 | 0.012 | 2.153 | 0.68 |
| Constant | −0.027 | 0.006 | 0.938 | 0.974 | - |

### *5.3. Differences in Teachers' Perceptions of STEM Teaching Based on Their Demographics*

Next, we assessed the statistical differences between teachers' measures based on their demographic differences (teachers' demographic distribution is given in Table 1). This was done by employing the Mann–Whitney U test between two groups and the Kruskal–Wallis H test in cases with more than two groups.

#### 5.3.1. Gender and Teaching Barrier

A Mann–Whitney U test was performed for SCTB scores based on gender groups. Results showed a statistically significant difference (U = 9704, $p = 0.047$) between the SCTB scores for male and female teachers. Female teachers (N = 136) had a higher mean rank of 160.15 than male teachers (N = 163), with a mean rank of 141.53. This illustrates that female teachers faced more barriers due to school-related issues than male teachers.

#### 5.3.2. Age Group and Teaching Barrier

A Kruskal–Wallis H test was performed for SCTB scores based on the age group of teachers. The analysis revealed a statistically significant difference in SCTB scores across teachers of different age groups, $\chi^2(3) = 11.486$, $p = 0.009$, between the mean ranks of at least one pair of groups. For the six pairs of groups, Dunn's pairwise tests were used. Teachers in the 30 and below age group (mean rank = 186.10) faced significantly higher school-related barriers than those in the 51 or older age group (mean rank = 120.68) ($p = 0.006$, adjusted using the Bonferroni correction). There was no evidence that the other pairs were different. This indicates that the extent to which teachers face school-related teaching barriers statistically differs based on age. Hence, age is a factor that affects the teachers in creating a barrier to STEM teaching, and this barrier is due to school-related issues.

#### 5.3.3. Grade Level of Teaching and Teaching Barrier

A Kruskal–Wallis H test was performed for SCTB scores based on the teachers' grade level of teaching. The analysis found a statistically significant difference in SCTB scores between the different grades that teachers taught in, $\chi^2(2) = 9.384$, $p = 0.009$, between the mean ranks of at least one pair of groups. Dunn's pairwise tests were used for the six pairs of groups. There was a marked difference between teachers who taught grade 12 and teachers who taught both grades 11 and 12 ($p < 0.01$, adjusted using the Bonferroni correction). There was no evidence that the other pairs were different. This reveals that the extent to which teachers face school-related teaching barriers statistically differs based on the grades they teach. Thus, grade level of teaching is a factor that affects the teachers in creating a barrier to STEM teaching, and this barrier is due to school-related issues.

#### 5.3.4. Graduation University and Teacher's Pedagogy

A Kruskal–Wallis H test was performed for TP scores based on the university education of teachers. Teachers reported having completed their university or college studies inside Qatar, at an Arab university outside Qatar, an American or European university outside Qatar, or an Asian or African university outside Qatar. The analysis discovered a statistically significant difference in TP score between the different universities from which teachers obtained their degrees ($\chi^2(2) = 11.862$, $p = 0.008$) between the mean ranks of at least one pair of groups. Dunn's pairwise tests were used. There was a significant difference between the group of teachers who graduated from an American or European University outside Qatar and those who graduated from an Asian or African University outside Qatar ($p = 0.015$, adjusted using the Bonferroni correction). Moreover, there was substantial evidence ($p = 0.033$, adjusted using the Bonferroni correction) of a difference between the group of teachers who graduated from an Arab university outside Qatar and those who graduated from an Asian or African University outside Qatar. There was no evidence showing that the other pairs were different. This indicates that the extent to which teachers apply pedagogical approaches in their classrooms statistically differs based on the university from which they graduated. Therefore, teachers' academic background influences their STEM pedagogical approach to teaching students.

## 6. Discussion

This study highlights salient barriers facing high school teachers in Qatar when teaching STEM. In this study, our analysis utilized various factors that predict these barriers and the results revealed associations between teachers' demographic characteristics and environmental (contextual) variables, student-related barriers, school-related barriers, pedagogical approaches, and teachers' classroom activities.

### *6.1. Barriers to STEM Teaching*

Social cognitive theory [49] and attribution theory [20,21] both provide a rationale for considering school context and other factors. As per the standardized beta weights, the context has a stronger relationship with teachers' perceptions than major background factors and personal opinions. This conclusion is corroborated by DeChenne and colleagues [50] in their study of 128 alumnus teaching assistants in STEM, which looked at the origins of teaching self-efficacy [50]. The study's findings showed that instructional self-efficacy is primarily influenced by the perception of the instructor's departmental and environmental aspects. In contrast to the current study's findings, the researchers discovered that environmental factors, such as the resources and allocated time, had a more significant impact than the peer-teaching relationship. Another study by [51] found a more profound link between instructors' self-efficacy and access to assets, as opposed to community support. Therefore, we assessed various environmental factors to understand the barriers teachers encountered in STEM teaching. This includes both school-related and student-related barriers.

The results derived from the present study disclosed three specific barriers to STEM teaching as reported by teachers: students' lack of the required skills, students' lack of the required knowledge, and students not having enough sleep. These results echo recent findings by [52–54]. These studies revealed that teachers noted that students often faced difficulty in solving STEM-related problems, did not perform well in academic areas, and were thus unable to apply their knowledge to self-directed STEM-related issues. While these problems may indicate that teachers felt their students lost interest in learning STEM, further empirical evidence is needed to explain how and why these challenges persist.

The decline in student interest was also reported to originate from a lack of parental and family involvement. These results corroborate findings of a study by [55], who concluded that parents' negative perceptions of STEM, particularly in communities bound by social or cultural norms, hamper teachers' STEM teaching. Indeed, several studies ascribe the decline in student STEM interest to a lack of parental and family involvement [56–61]. Prominent instances illustrating this decline include the absence of parental encouragement, lack of parental assistance with STEM subjects, and low parental aspirations or expectations [56].

The gains that parental involvement entails for students' STEM learning in particular are widely acknowledged in the literature [62–64]. Nevertheless, not all parents wanting to help their children can and know how to do so [57]. For example, parents' knowledge and understanding of the school's STEM curriculum may be limited. Different measures have effectively been used to bridge this gap between parents and children [65,66]. These possibilities for balanced STEM-related connections among children and households include school tasks, schoolwork responsibilities, after-school scientific associations, and trips to scientific centers. Community projects can also help build connections between children, parents, and educators. This provides added benefits to building constructive relationships with teachers, motivating them to be more competent in scientific training and teaching science more engagingly. Parent-teacher relationships can also be improved through such community-engaged STEM programs.

Grade level of teaching was found to yield substantial variances when analyzed against school-related teaching barriers. Our study's analyses indicated that the degree to which instructors experience school-related teaching barriers varies statistically depending on the grades they teach. Consequently, grade level of teaching is a factor that appears as a barrier to STEM teaching, which is caused by school-related concerns. This could be interpreted as implying that teachers who teach multiple grades are exposed to more teaching experience at school and are therefore more comfortable with the school-related activities.

The literature further indicates that teachers believe traditional school structures hinder effective implementation of STEM education [10]. School-related factors were measured as barriers to STEM teaching, as perceived by teachers, and assessed to determine significant differences between demographic factors. A Mann–Whitney U test for SCTB scores based on gender revealed a statistically significant difference between the SCTB scores for male and female teachers. Analysis estimates showed that female teachers faced more school-related barriers than their male counterparts. This finding has also been reported in previous work showing significant differences between female and male teachers' perception of STEM subjects [67–70].

Our study also examined whether school-related barriers facing teachers had any significant differences based on their age group. Results from a Kruskal–Wallis H test used to compare SCTB scores by teachers' age group demonstrated a statistically significant difference in school-related barriers teachers encountered based on their age groups. Consequently, teachers' age is a factor that can thwart STEM teaching. This could be due to younger teachers not being adapted to the school system or being perceived by the school in the same way as older teachers. Another possible reason could be due to young teachers being more critical of the school system as compared to older teachers. However, though previous literature has reported teachers' perception to be influenced by their experience and the time they have spent in the teaching profession [67,71–73], no reports have been made on the influence of school-related barriers based on the teacher's age.

### *6.2. Barriers to STEM Pedagogy*

Previous studies indicate that differences in teachers' demographics can affect their implementation of pedagogical approaches in classrooms [74–76]. Our study revealed a statistically significant difference in TP scores across the universities teachers graduated from. Moreover, it was revealed that the university that conferred teachers' degrees has a substantial impact on their likelihood to use pedagogical techniques in teaching STEM. This could be due to American, European, and Arab Universities being more aware of innovative pedagogical approaches than Asian and African Universities due to educational research being more prevalent in the former. This provides implications for educationists in Qatar to emphasize employing qualified teachers from American, European, and Arab Universities. Further, emphasis on training and developing teachers to use pedagogical practices in teaching STEM could enrich high school teachers' efficacy in teaching STEM.

Also, regression analysis results indicated that teachers aged under 50 were more likely to employ pedagogical approaches in their STEM teaching. This is not to be confused with our previous finding on young teachers facing more school-related barriers. In one case, age is a predictor for employing pedagogical approaches. However, in the other case, age has significant impact on barriers to STEM teaching (this is general STEM teaching and not specific to using pedagogical approaches in STEM teaching). Though no previous literature has been reported on this, young teachers having a higher likelihood of using STEM pedagogies could be due to them having a higher passion and enthusiasm to use innovative pedagogies. On the other hand, older teachers are more adapted to traditional pedagogies and show less interests in taking up new pedagogies. These findings have implications for enhancing high school STEM teachers' ways of teaching.

Regression analysis showed that teachers who used online tools as a resource while teaching students were more likely to apply STEM pedagogies. This demonstrates that online resources were more adaptive for teachers employing STEM pedagogies. Evidence reveals that not using adequate online tools makes it difficult for teachers to integrate the technology component of STEM into their lessons [36]. In a study conducted by Yildirim and other researchers [77], teachers argued that the use of online tools in STEM classrooms piqued their students' curiosity and enhanced their inventiveness; it also encouraged enthusiasm towards learning, increased pupils' digital literacy, personalized the learning process, and simplified complex ideas.

Another regression model revealed that teachers who used educational and research journals to teach challenging concepts were more likely to employ STEM pedagogies. Using scholarly information to support teaching practices has become a standard expectation in many fields. In our study, only 34.56% of the teachers reported using educational and research journals to teach challenging concepts. While a wealth of research may be utilized to improve instructional practices, little can be found in the literature regarding how much educators search, acquire, read, employ, and disseminate research findings to help them teach [78]. A 2020 study carried out by Booher and other researchers [79] noted that teachers are interested in research and acknowledge its importance in informing their practice. However, the study also reported that teachers face difficulty identifying strong research materials and figuring out how to use that research to improve their teaching. Therefore, there is a need to change the culture and practice of research application in the classroom by increasing teachers' perspectives and practices. Further research in this area is needed in order for teachers to improve their efficacy and improve student learning using research evidence.

## 7. Limitations

The study's conclusions must be viewed in light of its limitations. One of the limitations of this study lies in its sole reliance on survey data of high school teachers' perceived barriers to teaching STEM in Qatar. The study's analyses, as presented above, disclosed associations between the barriers teachers reported and their demographic attributes, contextual (school-related) characteristics, and student-related factors. These results would be improved with additional qualitative data. For example, personal follow-up interviews with teachers who reported barriers related to the pedagogical approaches and classroom activities used would aid in getting an in-depth and informed understanding of these barriers. Another limitation of the present study is its focus on high school teachers' perceived barriers. Indeed, the study would benefit from looking at data from teachers in lower levels of schooling. For example, investigating data from teachers in preparatory school grades would enrich the study's findings by offering a comparative perspective.

Moreover, our findings are applicable to our sample population of Qatar-based, urban, mostly middle-class teachers. Different outcomes are expected for instructors from various demographics and ethnic backgrounds. To some extent, all of these factors may influence the interaction of the variables. To overcome this constraint, a substantially larger sample population is required. Moreover, due to the limited sample size (N = 199), there may be minor fluctuations in the significant differences based on various variables. However, we believe that the use of logistic analysis (together with the very significant results obtained) encourages confidence in the findings of this study.

## 8. Conclusions

High school teachers' perceptions of the barriers that impede teaching STEM subjects, including student- and school-related influences, constitute the core of our study's analyses. Our findings revealed that although teachers reported a limited number of barriers, a few remain of concern. Student-related barriers included high school students' lack of skills, knowledge, and sleep which are perceived by teachers to affect STEM instruction. Moreover, gender-based differences existed in regard to teachers facing school-related barriers, with female teachers facing more barriers compared to their male counterparts. Age is another factor that determines teachers' perceptions of the barriers hindering STEM instruction: teachers aged 30 or younger tend to face more school-related barriers. Equally interesting, teachers' perceptions of the decline in student interest in STEM subjects seems ascribed to the lack of parental and family involvement.

The pedagogical approaches teachers adopted in STEM teaching appear to be affected by age, university education, and student-related factors. Teachers who employed more activities in their teaching process were more likely to use STEM pedagogies. In particular, teachers who used online tools and research journals are more likely to engage students through STEM-related pedagogies. These findings provide the direction to inculcate STEM education in Qatari high schools. Further research is required to investigate these important issues.

STEM teachers are an essential resource for the successful implementing of STEM education in Qatar. While student development is necessary to facilitate a harmonic STEM environment for teachers, training teachers is also critical. Teachers need to be empowered through professional development programs that target STEM-related pedagogies, especially for teachers with non-Western university degrees and those belonging to older age groups. Gender disparities among teachers need to be addressed.

Some of the student-related barriers reported by teachers can be overcome by revisiting the pedagogical approaches used in teaching STEM to motivate students and pique their interest in STEM [80]. Teachers can also use more STEM resources that could enhance students' STEM interest and improve their skills and knowledge [81]. Teachers also need professional development resources to effectively implement STEM teaching [82]. This will help teachers to develop a positive interaction with STEM concepts and methodologies. To enhance teaching integrity, instructional approaches related to STEM should be explicitly taught and demonstrated to teachers, especially those who graduated from Asian or African universities.

Furthermore, the efficient utilization and incorporation of online tools into STEM lessons necessitate collaboration between content developers and STEM educators, preferably at an early stage in the design process. This would help in the educational planning by implementing content compatible with STEM teachers' knowledge and requirements. Moreover, global business enterprises and educators now demand 21st-century skills. Shifting demographics and student diversity also necessitate a re-evaluation of instructional pedagogies and the role of technology in schools, homes, and communities. For both learners and instructors, regardless of their varying learning styles, digital resources present an opportunity for facilitating rational thought, investigation-based learning, problem-solving, and collaboration.

This study utilized questionnaire data to identify the barriers viewed to impede STEM education in high schools in Qatar from the teachers' perspective. The present study's analyses could be complemented and enhanced further with rich, in-depth qualitative information to gain real insights into the dynamics and complexities surrounding existing STEM teaching practices and the challenges that hinder effective STEM education.

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