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Investigating the individual interests of undergraduate students in STEM disciplines

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Despite massive investments in the education sector to empower youth in Qatar, a vital concern remains to retain students in science, technology, engineering, and mathematics (STEM) disciplines at the undergraduate level. Even though the country is committed to fostering a knowledge-based society, the low interest of undergraduates in STEM disciplines remains a vital challenge. To investigate this, the current study uses a survey methodology to investigate the perspectives of 172 undergraduate students to understand quantitatively the factors that influence their individual interests in STEM disciplines. Non-parametric significance tests and binary logistic regressions were employed to quantitatively measure the direct factors and predictors that affect students' individual interests. Findings indicated that aspects like students' reason/motivation to join STEM, their interaction with faculty, the habit of skipping classes, the difficulty faced in the curriculum, and their parents' highest educational qualification have an association with individual interests. Also, it was found that demographics such as age group, ethnicity, undergraduate discipline, undergraduate year, parent's employment status, and mother's highest educational qualification do not contribute to significant differences in students' individual interests. These conclusions provide important implications for educationists and policymakers to devise constructive reforms to enhance undergraduate students' individual interests, thereby improving their persistence in STEM.

KEYWORDS

educational reform, STEM persistence, capacity building, higher education, regression

1 Introduction

Despite the growing interest of high school students to pursue science, technology, engineering, and technology (STEM) disciplines (Board, 2012; Aud et al., 2013), researchers worldwide have called for attention to emphasize developments in undergraduate STEM education (Olson and Riordan, 2012; Shapiro et al., 2013). These concerns arise primarily due to the worrying graduation rates of students in undergraduate STEM (Chen, 2013; Lytle and Shin, 2020). Industry and business leaders are also concerned about a lack of outflux of STEM students from undergraduate levels. At the same time, several researchers have examined data trends and precited a shortage of STEM graduates over the next 10 years (Carnevale et al., 2011; Rothwell, 2013).

The case is similar in the Middle East, where gulf countries are lacking highly qualified STEM workers for their workforce (Babar et al., 2019). This has led to a paradigm change in several Arab countries, which are now recognizing robust educational systems as a vital component for achieving socioeconomic progress (Arar et al., 2024). Therefore, these nations are concentrating their efforts on capacity building in a deliberate manner to become a knowledge-based economy (Cherif et al., 2016). Similarly, Qatar has undergone significant educational reforms recently, establishing international branch campuses (IBCs) and introducing new policies (Morsy and Ibrahim, 2022). These reforms have aimed to provide academic opportunities and improve access to education with a focus toward STEM disciplines. This is highly important for the country, as there has been a noticeable lack of enthusiasm shown by its national students in pursuing careers in STEM fields (Said, 2016; Sellami et al., 2016, 2017; Said et al., 2018). This concern holds much significance in light of the country's national development vision, QNV2030, which calls for encouraging positive attitudes among national students toward STEM-related fields (Tan et al., 2014).

Research studies in both Qatar and worldwide have thus focused on the challenges that educational systems face in their efforts to raise the number of students who successfully enter and leave the STEM education system (Seymour, 2002; Singer et al., 2012; Ahmad et al., 2021; Sellami et al., 2022, 2023). Much of the attention is drawn to the reasons that contribute to students dropping out of STEM careers, including but not limited to students' interests, the nature of educational environments, and the teaching-learning practices employed (National Academies of Sciences and Medicine, 2016). Overcoming these factors is deemed essential for developing a sufficient pool of talent in STEM fields to help ensure economic strength, national security, and global competitiveness. For this, researchers have explored the sociocultural, behavioral, and institutional aspects of STEM education, correlating their influence on students' interests in subject disciplines and their perception of themselves as learners within these subject areas (Eccles et al., 1998; Perez et al., 2014). In particular, the aspect that affects students' performance is their involvement and perseverance in the educational environment, their experience in college, and their individual interests in the subject matter they pursue (Eccles et al., 1998).

Many of the studies in this regard have emphasized the individual interests of students in STEM, considering it to have a direct relationship with students' learning (Krapp and Prenzel, 2011). Here, individual interest in STEM can be defined as the cognitive and motivational variable that describes the engagement and motivation of the student in STEM disciplines (Renninger and Hidi, 2020). Additionally, there is broad consensus among researchers that students' individual interests affect how much they understand and, consequently, how much they know about a subject, making it the antecedent for learning (Rotgans and Schmidt, 2017). This viewpoint is called the "standard hypothesis of interest" (Rotgans and Schmidt, 2017). Reports from the literature have examined how individual interest is strongly associated with knowledge, offering numerous instances that support the validity of the conventional hypothesis (Renninger, 1992; Krapp, 1999; Hidi, 2001; Ainley, 2012). Moreover, it is theorized that students with high individual interests can be distinguished by their high intellectual commitment and affection for the specific academic field they are pursuing (Jansen et al., 2016). Theoretically, this perception was established by Renninger and Hidi (2019) and empirically supported by Jansen et al. (2019), the latter providing evidence from STEM disciplines. Corroborating this, studies indicate that individual interest has a considerable mediational impact on cognitive functioning when conceptualized as an interactive relationship between a student and an activity (academic field) and characterized by value commitment and positive energy (Köller et al., 2001). Several studies explicitly show that students' focus, recognition, and retrieval processes are significantly influenced by individual interests (Hidi, 1990; Wade, 2001). Students' persistence, concentration, level of absorption, active participation in tasks, and willingness to work are all influenced by their interest in the area of study (Hidi, 1990; Schiefele, 1991). Further evidence also points to a strong correlation between interest and the use of in-depth study methods (Schiefele, 1991; Ramsden, 2003). Students who develop their individual interest in a topic or possess an inherent curiosity about it are highly likely to participate in more exhaustive and meaning-oriented processing of the subject, generate more observations, remember a higher number of key concepts essential for appropriate comprehension of the topic, and (as a result) be superior at addressing more complicated issues and implementing their attained knowledge to real-world applications (Schiefele, 1991). Therefore, individual interests of a student provide the spark for all these qualities which in turn are deemed essential for their persistence and retention in undergraduate STEM disciplines (Ehrenberg, 2010).

Hidi and Renninger (2006), in their model for interest development, segregated interests into four distinct phases: (1) triggered situational interest, (2) maintained situational interest, (3) emerging individual interest, and (4) well-developed individual interest. The first two phases of situational interest are described by the student's focus, attentiveness, and positive response to educational environment changes; comprising of a triggering phase and an interest maintenance phase (Hidi and Renninger, 2006). Following the triggering of curiosity (phase one), attraction to the subject matter either rises (phase two) or diminishes (bounces back to phase one) depending on various external and internal factors such as the nature of the educational process, the extent of external support, and individual meaningfulness (Hidi and Renninger, 2006). The third and fourth phases (individual interest) are distinguished by a proclivity to reconnect with disciplinary material over time; they involve the development of an evolving individual interest mode, transitioning to its mature and well-developed version (Hidi and Renninger, 2006). A student becomes less reliant on outside assistance during these two phases, and progress in interest is more self-generated (Hidi and Renninger, 2006). In our case, following Hidi and Reninger's model, phase three corresponds to the period when a student enrolls in a STEM discipline (Renninger and Hidi, 2015), while phase four aligns with the stage where the enrolled undergraduate student expresses an intention to pursue a graduate degree in the respective STEM discipline (Knekta et al., 2020). It is crucial to note that the scope of the present study is constricted to the undergraduate level, where students have enrolled in STEM disciplines and, therefore, are in the third phase. It is important to note that this study does not delve into the factors that affect the transitioning of phases; rather, it gages the factors that affect the emerging and developed interests of phases three and four, respectively. This is important from an undergraduate perspective because the later phases of interest are influenced by various external factors rooted in sociocultural issues (Habig and Gupta, 2021). These may include gender, ethnic, or demographical differences (for example, underrepresentation of females in computer science disciplines), unpleasant interactions with instructors or educational environment (for example, an unsupportive teacher or a difficult curriculum), or even a frustrating learning experience that lacks adequate support (mismanagement of the disciplinary program) (Renninger and Hidi, 2011; Sax et al., 2017; Renninger et al., 2019). Therefore, from a sociocultural standpoint, while students can cultivate individual interest, the role of their relationship with the environment, such as their constructive social interactions, supports the proper development of interest (Renninger and Hidi, 2011; Pressick-Kilborn, 2015).

The expansion of STEM education faces significant barriers, from high attrition rates to low interest levels and enrollment rates (Rothwell, 2013). Therefore, a top priority in STEM education research is the investigation of the causes of low student persistence/retention to develop strategies for boosting their motivation and retention rates (Ehrenberg, 2010). Researchers have directly correlated the reasons for persistence and retention in STEM disciplines with individual interests (Thiry et al., 2019). Also, studies in the literature have adopted theoretical and quantitative measures to explore the factors that affect students' individual interests in STEM disciplines (Birbili and Tsitouridou, 2008; Knekta et al., 2020; Laine et al., 2020; Habig and Gupta, 2021; Höft and Bernholt, 2021; Ishak et al., 2022). However, studies from the undergraduate level pertaining specifically to the individual interests of students are limited. While it is crucial for research to investigate the persistence of undergraduate students, it is imperative to delve deeper into each factor that contributes to their persistence and retention, with individual interest being an important one (Knekta et al., 2020). Investigating the underlying factors that affect individual interests can directly lead to understanding students' persistence and retention (Maltese et al., 2014; Saleh et al., 2019; Asher et al., 2023). Therefore, this study gages the factors that affect undergraduate students' individual interests in STEM disciplines, providing important implications for educationists to strengthen student retention and persistence in STEM courses.

The research questions of this study are as follows:

- What factors directly affect the individual interests of undergraduate students in STEM disciplines?
- What predicts the likelihood of high individual interest in undergraduate students in STEM disciplines?

2 Materials and methods

In this study, we aimed to collect data on undergraduate students' individual interests in STEM to assess how various factors affect their interests. This section discusses the data collection methods, tools, and quantitative analyses used in the study.

2.1 Survey instrument

To investigate undergraduate students' individual interests, a survey was developed with the primary goal of collecting (a) demographic factors of students and (b) evidence that measures their individual interests in STEM.

2.1.1 Demographic and academic factors

The demographic survey items included student's gender, age group, ethnicity, undergraduate discipline, undergraduate year, parent's highest educational qualifications, and parent's employment status. Here it should be noted that for parent's employment status, students were asked if both parents were employed, only father was employed, or only mother was employed. Additionally, the survey included eight items that gaged students' academic factors (which can affect their individual interests), including their reason for joining STEM, classes enrolled per semester, their habit of skipping classes, frequency of changing major, involvement in research, plan for postgraduation, curriculum difficulty faced, and support by management. Single-option, multi-option, and unstructured-response questions were used to examine these factors.

2.1.2 Measures for individual interest

The survey was devised in a way to inculcate specific measures that assess the individual interests of students reported in the literature (Hidi, 1990; Schraw and Lehman, 2001; Hidi and Renninger, 2006). The selection of these measures was based on the determinants provided by Renninger and Hidi (2019)'s expanded descriptions of the relationship between interest and its development as conceptualized in the model of interest development. These determinants included learners' understanding, effort, feedback preferences, ability to set and realize goals, self-efficacy, and self-regulation. For this purpose, a five-point Likert scale was utilized. It was employed to incorporate determinants into eight closed objects, explicitly measuring students' individual interests. These objects included: updating themselves on course lessons before the class, practicing coursework after class, completing tasks and assignments on time, willingness to improve knowledge, willingness to concentrate on tasks, willingness to work hard on tasks, practice of following the university announcements, and practice of participating in the university activities. For each of these items, students were given response choices 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), and frequency questions (never = 1; rarely = 2; sometimes = 3; often = 4; always = 5). The survey instrument used was approved by Qatar University's Research Ethics Board (QU-IRB 1721-EA/22). The survey was offered in English.

2.2 Participants

The survey was sent to a random sample of undergraduate students at Qatar University, the country's largest national university. Responses were recorded during the year 2022. The survey required informed consent and was entirely optional, with the ability to leave anytime. The response rate to the questionnaire was 7%, while the sampling range of error was 2%. In total, 172 participants from various undergraduate STEM disciplines responded to the survey. The distribution was 84.3% females and 15.7% males at the individual level. This female majority proportion is a good representation of the undergraduate population in Qatar since, according to the Qatar Planning and Statistics Authority, 2019, Qatar has a similar undergraduate proportion (Newsome et al., 2022). In terms of ethnicity, 68% identified as non-Qataris and 32% as Qataris, which is also a close representation of the population in Qatar (Liloia, 2019).

About 36% of the total sample pursued their undergraduate degree in a science discipline, 33.1% in Engineering, and 30.8% in Medicine. Most students (63.4%) came from the 18–21 age group, and the majority were from Year 2 of their undergraduate degree (30.8%). Table 1 shows the student demographics of the sample size used in this research.

2.3 Data analysis

2.3.1 Individual interest score

This study uses individual interest score (IIS) as a measure computed from the survey results to quantify and assign a level of individual interest to each student (see Figure 1). Students were asked eight questions to define the extent to which they showed interest in their academics on a scale ranging from (1) Strongly Disagree/Never to (5) Strongly Agree/Always. These questions comprised of the following: practicing coursework after class to improve GPA, updating on course lessons before attending the lesson, completing tasks and assignments on time, performing extra tasks to improve knowledge, willingness to work hard on tasks, concentrating on tasks, following university announcements, and participating in activities. Students' responses to these survey items were coded into dichotomies by assigning a negative/neutral/positive value to the responses, indicating low/neutral/high individual interests. The scores of these eight survey items were summed to obtain a single IIS ranging from −16 to 18. This score represented the overall magnitude of each student's individual interests in STEM disciplines.

TABLE 1 Student demographics.

Variable	Sub-categories	Percentage	*N*
Gender	Male	15.7	27
	Female	84.3	145
Age Group	Under 18	2.9	5
	18 to 21	63.4	109
	22 to 25	27.3	47
	Over 25	6.4	11
Ethnicity	Qatari	32.0	55
	Non-Qatari	68.0	117
Undergraduate discipline	Science	36.0	62
	Engineering	33.1	57
	Medicine	30.9	53
Undergraduate Year	Foundation Program	2.3	4
	Year 1	16.3	28
	Year 2	30.8	53
	Year 3	23.3	40
	Year 4	19.8	34
	Year 5	5.8	10
	Year 6	1.7	3
Parents employment status	Father only	45.9	79
	Mother only	7.6	13
	Both father and mother	30.2	52
	N/A	16.3	28
Father's highest educational qualification	School Level	27.3	47
	Undergraduate	39.5	68
	Postgraduate	30.8	53
	N/A	2.3	4
Mother's highest educational qualification	School Level	31.4	54
	Undergraduate	42.4	73
	Postgraduate	21.5	37
	N/A	4.7	8
Reason to join the STEM discipline	Self-motivation	81.4	140
	Friends and family motivation	18.6	32

$N = 172$.

The survey validation was performed using factor analysis with principal components method to achieve a solution with correlations greater than 0.3 between the item and the component. Initially, nine items were used in the first step of the factor analysis. Due to a low correlation of an item with the factor, the item was discarded to achieve the component with eight items (component loadings given in Table 2). The dimensionality of the scale is represented by the Kaiser-Meyer-Olkin (KMO) and Bartlett's test of sphericity, yielding a KMO value of 0.737 with statistical significance ($p < 0.001$), thereby confirming the unidimensionality of the construct (Yong and Pearce, 2013). The reliability of the scale was assessed to demonstrate the internal consistency and dependability of the score using Cronbach's alpha (α). Researchers (Cohen et al., 2002) claim alpha values above 0.70 are dependable, and those above 0.90 are exceptionally reliable. The survey's calculated alpha was 0.720 indicating the scale to be reliable. The descriptive statistics and reliability of the IIS are presented in Table 3.

2.3.2 Statistical analysis

The data was analyzed using IBM SPSS Statistics (Version 28.0). Summarizing statistics like means and percentages were used to compare the demographic data. Various tests were selected based on the statistical measurements and distributions of the data (Heeringa et al., 2017; Pallant, 2020). Significance tests were used to statistically establish differences in IIS between various demographic and academic groups. The Shapiro–Wilk test for normality was used to check the data distribution to choose between parametric and non-parametric significance tests. While independent samples T-test and one-way ANOVA were used for normally distributed data, the Mann–Whitney U and Kruskal–Wallis H tests were applied for data with skewed distributions. Also, Levene's test for homogeneity of variances was used to estimate equality in variances. Furthermore, if the ANOVA yielded statistically significant results, the Tukey *post hoc* test was used to conduct the *post hoc* tests. Similarly, in the case of statistically significant outcomes for the Kruskal–Wallis H test, Dunn's test was used to compare each independent group pairwise. Furthermore, the Bonferroni adjustment was used when running the Kruskal-Wallis test because the stated significance level may be acceptable for individual comparisons rather than the set of all comparisons. To go beyond simple descriptive analyses, binary logistic regression was used to assess the relative strength of the relationship between various predictor

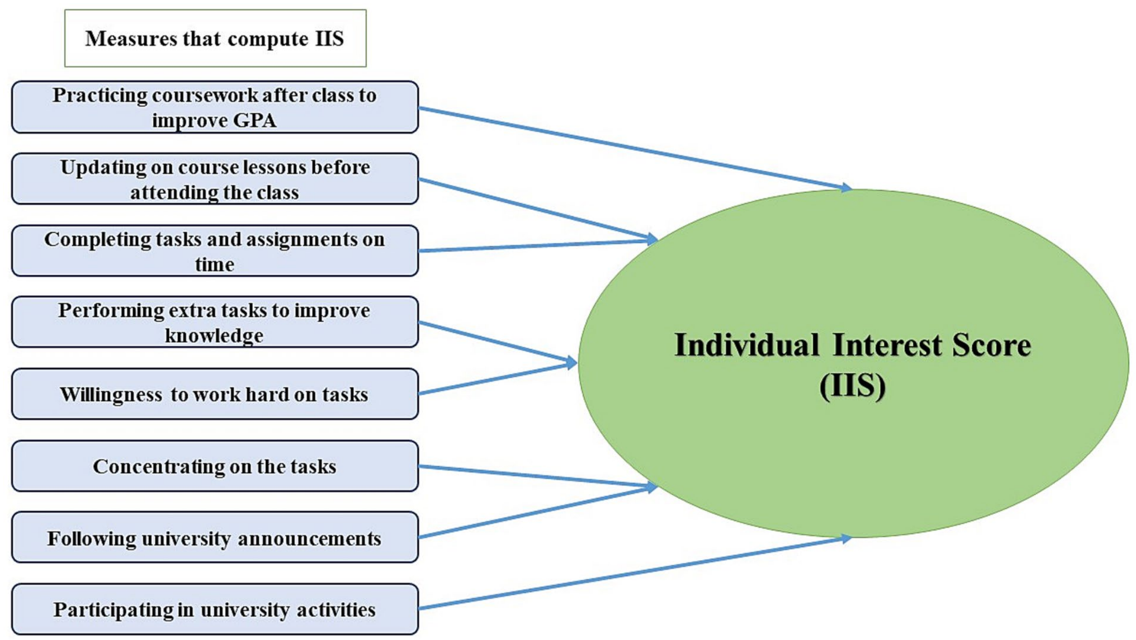

FIGURE 1
Specific individual interest measures which compute the overall IIS measure.

TABLE 2 Component loadings of the factor analysis.

Survey items	Component loadings
I concentrate as hard as possible when doing a task	0.784
I am willing to work as hard as possible on tasks	0.726
I am willing to do extra work on tasks to improve my knowledge	0.664
I practice on my coursework after class to improve my GPA scores.	0.603
I complete tasks and assignments on time	0.583
I constantly update myself on the course lessons before attending the lessons	0.569
I regularly participate in the activities launched by your university	0.338
I have the practice of following the university announcements	0.415

Extraction Method, Principal Component Analysis.

TABLE 3 Descriptive statistics and reliability of the IIS measure.

Variable	Construct validity				Descriptive statistics					
	No. of items	Cronbach alpha	Kaiser–Meyer–Olkin (KMO) value	*p*	Mean	Median	SD	Range	Minimum	Maximum
Students' individual interests	8	0.720	0.737	<0.001	8.88	9.00	4.81	25.00	−7.00	18.00

$N = 172$.

variables (demographic and academic factors) and the likelihood of high IIS. When the outcome variable is binary or dichotomous, and the predictor variables are categorical or continuous, binary logistic regression is an effective analytical method (Peng et al., 2002). Odds ratios measured the association between the factors and possible outcomes. The alpha level was set as 0.05 for all the statistical tests.

3 Results

This section presents the results of the statistical analyses performed to gage the factors affecting undergraduate students' individual interests. Normality tests were performed before conducting significance tests, the results of which are detailed in the Supplementary file.

TABLE 4 Independent samples *t*-test for overall IIS based on students' reason to join STEM discipline.

Variable	Variances	Levene's test for equality of variances		*t*-test for equality of means			
		F	Sig.	*t*	df	One-sided *p*	Two-sided *p*
IIS	Equal variances assumed	0.346	0.557	−2.255	170	0.013	0.025[1]
	Equal variances not assumed	–	–	−2.190	44.821	0.017	0.034

[1]Self-motivation (Mean = 8.49), Motivation by friends and family (Mean = 10.59).

3.1 Association of individual interests with students' reason to join STEM discipline

Students were asked to state their reason for joining STEM disciplines (Wang and Degol, 2013; Gottfried et al., 2017; Mwangi et al., 2021; Luo et al., 2023; Whitehead et al., 2023). While the majority of the students (81.4%) acknowledged self-motivation to be the cause, some students (18.6%) were identified to be motivated by their friends or family. Shapiro–Wilk's test of normality was performed on these sample sizes against the IIS measure, which yielded the populations to be normal ($p > 0.05$) (see Supplementary Table S1). Therefore, independent samples t-tests were used to measure significant differences in IIS based on students' reason for joining STEM. Table 4 demonstrates the results of the T-test. Levene's test for homogeneity of variances indicated equal variances to be assumed ($p > 0.05$). The T-test was found to be statistically significant with $p = 0.025$. Interestingly, the results indicated that students motivated by their family and friends to join STEM disciplines had higher individual interests (Mean = 10.59) than those who were self-motivated to join STEM (Mean = 8.49).

3.2 Association of individual interests with students' interaction with faculty

Students were asked about their frequency of interaction with faculty outside the formal learning environment. While a majority of the students were observed to interact once a month (37.7%), a sizable population stated to interact twice a month (19.7%), 1–2 times a week (19.7%), and 3–4 times a week (13.9%). Very few students stated that they interacted with faculty on a daily basis (8.7%). These frequency groups were compared against the overall IIS of students. Since the Shapiro–Wilk's normality test results (see Supplementary Table S2) indicated a normal distribution ($p > 0.05$), a one-way ANOVA test was used to measure any significant differences. Findings showed statistically significant differences between the frequency groups with $p < 0.001$ (see Table 5). Further, Tukey *post hoc* tests were conducted to reveal that students who interacted with faculty daily tended to have higher individual interests (Mean = 13.13) than those who interacted twice a month (Mean = 7.05) or once a month (Mean = 8.00). Students who interacted 3–4 times a week (Mean = 10.20) and 1–2 times a week (Mean = 9.58) also had higher means than those interacting monthly or bi-monthly, though these differences were not statistically significant.

TABLE 5 One-way ANOVA tests for overall IIS based on students' interaction with faculty outside classes.

IIS measure[a]	Sum of squares	df	Mean square	*F*	Sig.
Between groups	493.865	4	123.466	5.953	0.000[1]
Within groups	3463.809	167	20.741		
Total	3957.674	171			

[a]Grouping Variable: Students' interaction with faculty outside classes, Daily ($N = 15$), 3–4 times a week ($N = 24$), 1–2 times a week ($N = 34$), Twice a month ($N = 34$), Once a month ($N = 65$). [1]Tukey Post Hoc Test: Significant differences between Daily (Mean = 13.13), Twice a month (Mean = 7.05), Once a month (Mean = 8.00).

3.3 Association of individual interests with students' habit of skipping classes

Students were asked if they had a habit of skipping classes. Many students responded in the negative (57.5%); however, a large population admitted their habit of skipping classes (42.4%). These sample sizes were compared against the overall IIS measure. Results of the Shapiro-test Wilk's of normality revealed that the populations were normal ($p > 0.05$) (see Supplementary Table S3). As a result, independent samples T-tests were performed to assess any notable variations in IIS based on students' habit of skipping classes. The T-test results are shown in Table 6. According to Levene's test for variance homogeneity, unequal variances are presumed ($p < 0.05$). The significance test yielded statistically significant results with $p = 0.022$. These findings revealed that students who had a habit of skipping classes developed lower individual interests (Mean = 7.87) as opposed to those who did not (Mean = 9.62).

3.4 Association between other demographic factors such as age group, ethnicity, undergraduate discipline, undergraduate year, parent's employment status, and mother's highest educational qualification

Students' individual interests were also examined based on the other demographic factors listed in Table 1. Since the Shapiro–Wilk's normality test results (see Supplementary Tables S10–S15) indicated normal distributions ($p > 0.05$), independent samples T-tests and one-way ANOVA tests were used to measure any significant differences against the overall IIS measure. Findings showed that there were no statistically significant differences between the frequency groups for any of these factors ($p > 0.05$) (see Supplementary Tables S16–S21). In

TABLE 6 Independent samples *t*-test for overall IIS based on students' habit of skipping classes.

Variable	Variances	Levene's test for equality of variances		*t*-test for equality of means			
		F	Sig.	*t*	df	One-sided *p*	Two-sided *p*
IIS	Equal variances assumed	4.107	0.044	−2.390	170	0.009	0.018
	Equal variances not assumed	–	–	−2.318	136.014	0.011	0.022[1]

[1]Yes (Mean = 7.87), No (Mean = 9.62).

TABLE 7 Binary logistic regression of the associations between gender, curriculum difficulty, father's educational qualification, and visit to academic counselor on student's likelihood of having high individual interests.

Variable	*B*	Wald χ^2	*p*	Exp(B)
Gender	0.058	0.015	0.903	1.060
Curriculum difficulty	0.782	4.921	0.027	2.185
Father's highest education	–	14.017	0.003	–
Father's highest education (Undergraduate)	−0.806	3.980	0.046	0.446
Father's highest education (Postgraduate)	0.795	3.082	0.079	2.215
Father's highest education (N/A)	−0.142	0.017	0.896	0.868
Frequency of visits to academic counselors	–	3.808	0.149	–
Frequency of visits to academic counselors (2–5 times per semester)	0.075	0.044	0.833	1.078
Frequency of visits to academic counselors (More than 5 times)	2.252	3.803	0.051	9.504
Constant	−0.098	0.031	0.861	0.907

Sample size = 172.

other words, the factors including age group, ethnicity, undergraduate discipline, undergraduate year, parent's employment status, and mother's highest educational qualification do not contribute to any significant differences in students' individual interests.

3.5 Association of individual interests with father's highest educational qualification and curriculum difficulty

A binary logistic regression model was used to determine the factors associated with the likelihood of students having a high individual interest. These factors include the student's gender, the student's father's educational qualification, their perception of curriculum difficulty, and their frequency of visits to academic counselors. For this, the dependent variable was chosen to be the overall IIS measure, which was coded into dichotomies for the regression model. IIS greater than 8 was coded as "1" and IIS less than or equal to 8 as "0." IIS score of 8 was chosen as the threshold based on the rationale that a student with the least possible positive response (Agee/Sometimes, i.e., = 1) for each survey item would have a total score of 8, since eight survey items (negative scores need to be neutralized by counter positive scores). Therefore, for a score greater than 8, it is proposed that the student would most definitely have high individual interests. The proposed regression model indicated the chances of having high individual interests (ODDS) = *f*(gender, curriculum difficulty, father's highest educational qualification, and frequency of visits to academic counselors). Upon analysis of the complete regression model to an intercept-only model using Omnibus Tests of Model Coefficient, the model indicated significant improvement in fit as compared to the null model ($\chi 2$ (7) = 21.381, p = 0.003). The Hosmer and Lemeshow test was used to evaluate the goodness of fit of the logistic regression model. The test yielded $\chi 2$ = 2.378 and p = 0.967, showing that the logistic regression model fits the data very well (Fagerland and Hosmer, 2012). Further, the Nagelkerke R^2 (adjusted version of Cox & Snell R^2) assessed the model's predictability to be 0.157. The high corresponding Log Likelihood statistic was 212.483, indicating that the overall model is fit (Nagelkerke, 1991). The regression revealed that students who perceived difficulty in the curriculum were less likely to have high individual interests (odds ratio = 2.185). Additionally, students' fathers' highest educational qualification was a statistically significant predictor of their likelihood of having a high individual interest. Students whose father's highest educational qualification was postgraduate were more likely to have high individual interests compared to others whose father's highest educational qualification was school level (odds ratio = 2.215). Lastly, gender and frequency of visits to academic counselors were not statistically significant predictors of student's likelihood of having high individual interests. The results of the regression are summarized in Table 7.

4 Discussion

While previous literature on STEM Education acknowledges the factors that motivate students to pursue STEM (Robinson and Ochs, 2008; Hall et al., 2011; Hossain and Robinson, 2012; Wang, 2013; Wang and Degol, 2013), there is a dearth of studies that explore students' individual interests after they enter into STEM disciplines. Though the present study does not assess the retention of students in STEM, this

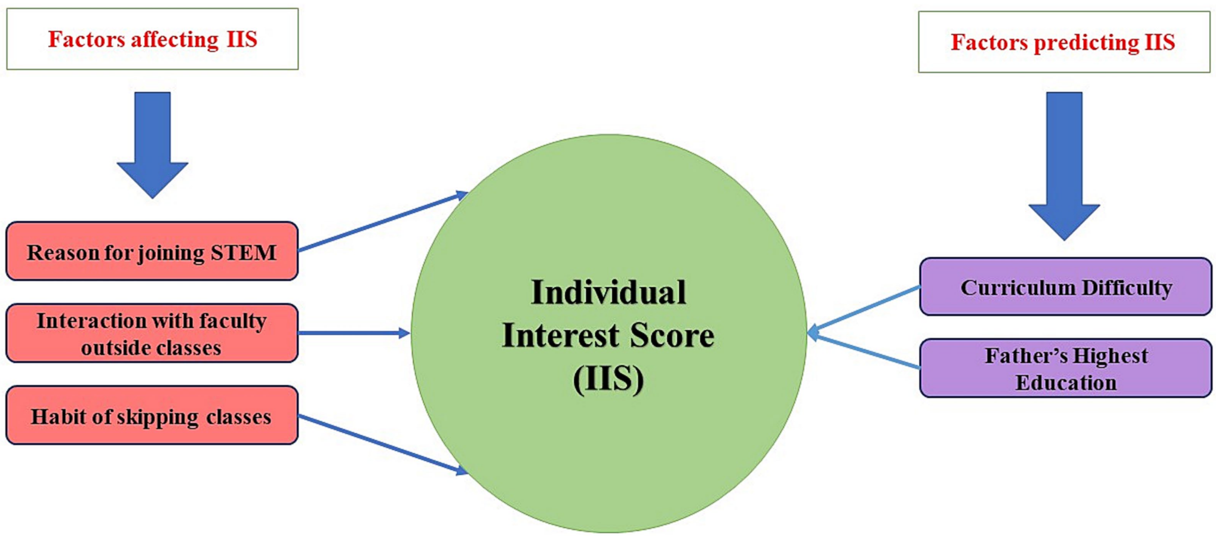

FIGURE 2
Summary of the analysis: factors that affect IIS and factors that can predict IIS of undergraduate students.

study focuses on determining what factors influence students' personal interests while pursuing STEM disciplines. The data discovered that the motivation behind students' entry into undergraduate STEM affects their individual interests later while pursuing the degree. Furthermore, their interaction with faculty members outside classrooms, their habit of skipping classes, and their perceived difficulty with the curriculum are significant indicators of their individual interests in STEM. Interestingly, the father's highest educational qualification significantly predicted students' high individual interests in STEM. A summary diagram is presented in Figure 2. Furthermore, it was observed that demographic factors such as age group, ethnicity, undergraduate discipline, undergraduate year, parent's employment status, and mother's highest educational qualification do not contribute to significant differences in students' interests.

While these findings reported by the present study are unique to undergraduate STEM education, several studies in the literature help corroborate these findings. For instance, significant differences were found in students' individual interests based on the motivational reason for their entry into STEM. This was interesting because students who reported being motivated by their friends and family to join STEM showed higher individual interests than those who joined STEM due to self-motivation. Viewed holistically, family and friends being a factor was proposed by Barron (2006) through a 'learning ecosystem' model as 'the set of contexts found in physical or virtual spaces that provide opportunities for learning' (p. 195). Earlier studies have also stated that parents significantly impact their children's drive to study and embrace science in particular (Perera, 2014). Moreover, parental and family encouragement increases students' interests and engagement in STEM, and these benefits are mediated through the effects on children's scientific interests and confidence (Nugent et al., 2015; Sha et al., 2016). This motivation given by parents, family members, and friends significantly influence a child's likelihood of sustaining STEM aspirations across time (Archer et al., 2014; DeWitt and Archer, 2015, 2017). Therefore, students receiving higher levels of motivation are more inclined to express such desires than their peers with lower levels. However, the reason for lower individual interests of students self-motivated into STEM cannot be ascertained, as there are no reports on this in the literature. Nevertheless, this finding could be a unique finding for undergraduate students in Qatar, and therefore future studies are required to investigate the reasoning behind it. Finally, this finding related to parental authority on individual interests in STEM is consistent with the aspects of social cognitive theory (Bandura, 1977) and self-determination theory (Deci and Ryan, 2004), which are constantly required in the educational process to fulfill the requirements of students and endorse the findings of STEM education community on the persistence of student readiness to succeed for the STEM profession.

The current study also found that interaction with faculty outside classes significantly affected STEM students' individual interests. More specifically, students with a higher frequency of interaction with faculty outside their classes were found to have superior individual interests. This finding is supported by substantial research from the last decade published by the National Academies of Sciences, Engineering, and Medicine (National Academies of Sciences and Medicine, 2016), which indicated that perseverance in STEM is linked to various factors other than academic readiness, including interaction with faculty outside the classrooms. Moreover, faculty attitudes and behavior in and out of the classroom can provide indications that encourage students' persistence in STEM degrees. Their study also reported that when exposed to interactions with faculty, students enhance their expectations, actions, and ideologies of STEM. Depending on the nature of these interactions, students may be pushed into isolation, disaffection, or giving up on their STEM objectives, or they may be encouraged to embrace a STEM identity and thrive in a STEM community where there is validation and support. Furthermore, the study claimed that effective interventions in STEM need to include undergraduate students' interaction with faculty members. Another study by the National Research Council (Singer et al., 2012) pointed out the importance of increasing interaction with faculty and teaching assistants for formulating an active instructional practice.

Another significant factor affecting students' individual interests in STEM was their habit of skipping classes. Students who admitted to skipping classes were found to have lower individual interests than those who did not skip classes. This finding can be correlated with the results of a comprehensive meta-analytic study by Marcus et al. (Credé et al., 2010), which reported class attendance as a strong predictor of undergraduate students' academic characteristics and behavior. Moreover, their study established class attendance to dramatically increase students' grades and GPA. Furthermore, this relationship between class attendance and interests in STEM is consistent with learning and training theories that highlight the need for recurrent and extended engagement with attending classes (Credé et al., 2010; Rumberger and Rotermund, 2012). In theory, students' interests are believed to be the bridge between student attendance and GPA (Batres, 2011). If students have improved attendance levels, it directly correlates with their enhanced individual interests, which in turn helps them achieve high attendance and GPA. Therefore, it is crucial for educators and decision-makers to emphasize improving the attendance of undergraduate students in STEM disciplines. Moreover, further research on attendance could help gage its association with the rate of dropouts in undergraduate STEM.

This study also drew an association between the average number of courses (i.e., credit hours) enrolled per semester by the student and their individual interests. While no significant differences were found in assessing the overall measure of individual interests, two specific measures of IIS were found to have substantial differences (see Supplementary Tables S4, S5). These measures included students' willingness to work hard and participation in university activities. Students who enrolled for 4 or fewer courses per semester (on average) were found to be significantly more willing to work hard and more likely to regularly participate in university activities than those with 5 or more courses enrolled. This indicates that a high number of courses per semester affects students' self-efficacy and engagement in STEM. This could be because of the workload, time commitments, and pressure the students face when they register for a large number of courses. Previous literature shows that the number of credit hours can affect students' GPA [63] and may lead to their college dropout (Metzner and Bean, 1987). These conditions may arise due to students developing a low self-efficacy engagement in STEM when enrolling for a high number of courses, which eventually lowers their interest in STEM. Furthermore, studies have mentioned that undergraduate students suffer a lot of physical and mental stress throughout the year (Das et al., 2021; Fauzi et al., 2021), affecting their exam grades (Hsieh et al., 2012; Kurata et al., 2015). This can be connected with students' low individual interests, which arise from enrolling in many credit hours.

Some other factors that could affect undergraduate students' likelihood of having a high individual interest were assessed using a binary logistic regression. It was observed that students who reported facing difficulty in the curriculum were less likely to have high individual interests. While this difficulty may be due to taking a high number of courses, it can also happen due to several other student-related, teaching-related, or university-related barriers. Educationists and universities must identify the challenging courses or concepts in STEM curriculums and devise/implement suitable evidence-based instructional practices to overcome this challenge. Institutions can provide more personalized learning to remove difficulties in curriculum with a deeper understanding of the obstacles that students face and when and why they face them. Furthermore, the regression also found that students' father's highest educational qualification was a statistically significant predictor of their likelihood to have a high individual interest. Students whose father's highest educational qualification was postgraduate were almost two times more likely to have high individual interests than others whose highest educational qualification was at the school level. This can be attributed to the study by Hishan (2020), which found father's education to be a significant factor affecting a student's cognitive capacity. Correlating to this, the present study also found that there exist significant differences for a specific measure of individual interest based on the mother's highest educational qualification (see Supplementary Tables S6, S7). Students whose mothers had a postgraduate degree were likelier to update their course lessons before attending classes (signifying their self-efficacy) than those whose mothers possessed an undergraduate degree. Though this effect was not for the overall individual interest measure, it contributes to the effect of parents' education on student's individual interests. Lastly, the determination to complete tasks and assignments on time was also found to be significantly different for students based on their plans for postgraduation. Students who responded to having a plan for their postgraduation degrees were significantly more determined to complete tasks and assignments on time than those who responded in the negative (See Supplementary Tables S8, S9).

5 Conclusions, limitations, and future directions

This study explored the individual interests of undergraduate students in STEM disciplines. It was established that statistically significant differences in students' individual interests were based on their motivational reason to join STEM, their habit of skipping classes, and their interaction with faculty outside class hours. It was also demonstrated that students' individual interests could be predicted by their difficulty in the curriculum and their father's highest educational qualification. Moreover, it was observed that demographic factors, including age group, ethnicity, undergraduate discipline, undergraduate year, parent's employment status, and mother's highest educational qualification, do not contribute to any significant differences in students' overall individual interests. These findings are unique to the undergraduate STEM literature in assessing students' individual interests, a subject matter that has largely been understudied.

Like many other studies, the current findings must be interpreted within the context of their limitations. First and foremost, these conclusions are solely applicable in the context of the sample population: Qatar-situated, urban, primarily middle-class undergraduates. Different results are expected for students from different demographics and ethnic origins. All these factors could impact the interaction of the variables to some extent. A significantly more significant sample population is necessary to overcome this constraint. Secondly, due to a comparatively small sample population ($N = 172$), there could be slight variations in the significant differences based on some variables. However, the use of logistic analysis (together with the very significant results obtained) lends credibility to the results of this study. Also, this study's data was entirely based on students' self-reports, subjective recollections, and perceptions. Although it has been suggested that students' opinions are important and significant for understanding their individual interests, a more comprehensive inquiry should consider various perspectives (e.g., instructors, parents, and classmates). Further, it is important to note that the present study is situated to gage the factors that affect undergraduate students' emerging and developed interests contained in phases three and four of the theoretical model. Future studies are urged to evolve through this limitation and perform a larger scoped study on the transition of the four phases of individual interest development, preferably throughout a high school to undergraduate journey.

Furthermore, undergraduate STEM students' individual or personal interests remain an understudied field reported in the literature. More comprehensive research is required in this area, which will not only help increase students' persistence in undergraduate STEM but also contribute to developing students' career orientation toward STEM jobs and postgraduation studies. Further research could also delve into the trajectory of individual interests of students pre and post their undergraduate degrees. This could include evidence from different grade levels (e.g., primary, preparatory, secondary) in K-12 education and postgraduation studies. Evidence from other countries is also vital to adding evidence to the conclusions of this study.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the survey instrument used was approved by Qatar University's Research Ethics Board (QU-IRB 1721-EA/22). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MA: Conceptualization, Formal analysis, Methodology, Writing – original draft. NS: Conceptualization, Methodology, Writing – review & editing. SK: Investigation, Writing – review & editing. AA-T: Investigation, Writing – review & editing. AS: Project administration, Writing – review & editing. FT: Project administration, Writing – review & editing. JB: Project administration, Writing – review & editing. NA-T: Project administration, Writing – review & editing. ZA: Conceptualization, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1285809/full#supplementary-material

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