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Attitudes toward science among grades 3 through 12 Arab students in Qatar: findings from a cross-sectional national study

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ABSTRACT

This study assessed students' attitudes toward science in Qatar. A cross-sectional, nationwide probability sample representing all students enrolled in grades 3 through 12 in the various types of schools in Qatar completed the 'Arabic Speaking Students' Attitudes toward Science Survey' (ASSASS). The validity and reliability of the 32-item instrument, encompassing five sub-scales, have already been shown to be robust. The present analysis focused on responses from 1978 participants representing the students who completed the ASSASS in Arabic. Descriptive statistics were computed and a competing pair of multiple indicators multiple causes models is presented that attempt to link patterns in students' responses to the ASSASS with a set of indicators. The final model retained student age, gender, nationality (i.e. Qatari vs. Non-Qatari Arab), and school type as indicators. Findings from this study suggest that participants' attitudes toward science decrease with age, and that these attitudes and related preferences are influenced by students' nationality and the type of school they attend. Equally important, the often-reported advantages for male over female precollege students in terms of attitudes toward science were much less prominent in the present study.

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Attitudes toward science; precollege; Qatar; cross-sectional design; national sample

The state of Qatar boasts a population of two million people, with Qatari and other Arab nationals constituting about 40% of the population. The remainder of the nation's residents comprise Non-Arab expatriates (Central Intelligence Agency, 2013). Located on the Persian Gulf, affluent with oil and natural gas commodities, Qatar is one of the wealthiest countries in the world (World Economic Forum, 2009). With this wealth Qatar has demonstrated a strong commitment to, and willingness to invest in, education. The Qatar Foundation for Education, Science and Community Development was launched nearly 20 years ago with a multi-billion-dollar endowment and aims, among other things, to build within Qatar a research culture that 'encourages the pursuit of new knowledge, conducts scientific research, and develops new technologies' (Qatar Foundation, 2009). Despite the availability of Qatari funding and resources, current prospects for

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realizing the aforementioned goals in Qatar, as with other Arab nations, continue to be met with significant challenges.

The Arab Human Development Report (United Nations Development Programme [UNDP], 2003), which specifically spoke to scientific production in Arab countries, told 'a story of stagnation in … scientific research' (p. 23). Specifically, the UNDP (2003) report draws attention to two, likely interrelated, concerns related to scientific research and production in Arab countries: the almost total absence of advanced research in certain fields (e.g. information technology and molecular biology) and the low number of qualified science and engineering (S&E) workers. To quantify these concerns, consider that as of 2012 Qatar had a mere 597 research and development professionals, or scientists, per million inhabitants (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2014a). This compares to 1036 per million in China and 4019 in the USA (UNESCO, 2014b, 2014c). Also related to the latter concern is the number of Arab students enrolling in scientific disciplines in higher education, which is similarly low. In its 2008 report 'The Road not Traveled—Education in the Middle East and North Africa,' the World Bank indicated that only 20% of university students in most Arab countries are enrolled in S&E compared, for instance, to 47% in China. The situation in Qatar is analogous with only 19% of college students enrolled in these disciplines (The World Bank, 2008). Qatar University's statistical summary substantiates the World Bank finding, indicating that over recent years less than 12% of students annually enrolled in S&E programs (Qatar University, 2008).

The prosperity of a national scientific enterprise—in Qatar as elsewhere—hinges on the steady supply of qualified S&E professionals in all scientific fields and domains, which in turn hinges on the preparation of highly qualified, diverse, and motivated learners in the sciences at every stage of the academic pipeline (Galama & Hosek, 2008). Through the Qatar Foundation, Qatar has attracted branch campuses of some of the best universities in the world (Brewer et al., 2007, p. xvii). Nonetheless, the extent to which investment in higher education works to advance a scientific culture of research and practice largely depends on 'inputs,' especially in terms of precollege school graduates who opt to pursue, and persist in, college studies in scientific fields. To bolster the science education pipeline, and to hopefully ensure that Qatari students take advantage of the opportunities made available to study scientific disciplines, Qatar needs more robust outcomes from its elementary and secondary education system.

In 2002 the 'Education for a New Era' reform initiative brought a sweeping, multistep plan to rejuvenate the Qatari educational system (Zellman et al., 2009). Stasz, Eide, and Martorell (2008) explained the need for this reform, stating that 'the education system for kindergarten through grade 12 (K-12) does not adequately prepare Qataris for work or post-secondary study' (p. 13). As part of the reforms, the year 2004 witnessed the introduction of new precollege school curriculum standards in Arabic, mathematics, science, and English for all grade levels. These new curriculum standards are comparable to the highest in the world, and the mathematics and science standards were published in Arabic and English to make them accessible to the largest group of educators (Brewer et al., 2007). This new curriculum was intended to address the widely agreed upon concerns that the elementary and secondary education system in Qatar is rigid and outmoded (Brewer et al., 2007), with an emphasis on rote memorization (Zellman et al., 2009). In addition to curricular changes, the reform model also outlined solutions for deficits

attendant to school autonomy, teacher shortages, and resource allocation (Brewer et al., 2007).

As with many other Arab countries, the situation in Qatar entails an urgent need for increasing Qatari student enrollment and involvement in the sciences at the college level. While the problem is no doubt multifaceted, it seems reasonable to infer that by the time students reach college or are in a position to choose their university major, only a small minority of Qatari and Arab students seem to have developed the interest, attitudes, and/or perceived ability or preparedness to elect pursuing a college major in the sciences. Relevant to this state of affairs, the research literature depicts a well-established relationship between affective variables and precollege students' learning and achievement (e.g. Ainley, Hidi, & Berndorff, 2002; Hidi, 1990; Tobias, 1994) particularly in science (e.g. Chang & Cheng, 2008; Laukenmann et al., 2003), as well as student career choice and decisions to pursue scientific studies (e.g. Calabrese-Barton & Basu, 2007; Mason & Kahle, 1989).

Purpose

The low numbers of S&E professionals, and students enrolling in related fields at the tertiary level, in Qatar are a concern shared by researchers and policy-makers in other nations. Qatar is set apart from other contexts because of the near absence of S&E professionals, with only a small minority who reached those fields through an in-country pipeline. The present study was part of an extensive project titled 'Qatari students' Interest in, and Attitudes toward, Science' project (QIAS, which transliterates into 'measurement' in Arabic). Among other goals, QIAS aimed to (a) Gauge school students' attitudes toward science in Qatar and changes in these attitudes as students progress through formal schooling, specifically from grade 3 through grade 12; and (b) examine factors that impact student attitudes toward science. To better focus on the impact of any contributing factors, which will be outlined in the next section, and related findings, if any, the authors have elected to restrict comparisons to within the Arab culture by examining Qatari students and Non-Qatari Arabs. As such, this manuscript reports on the above goals as they apply to Arabic-speaking students in Qatar, that is, Qatari and Non-Qatari Arabs (knowing that Qatar is host to substantial communities of Non-Arab ex-patriot residents). Using a cross-sectional design and drawing from a random national sample of class sections, this study aimed to measure attitudes toward science among Arabic-speaking students in grades 3 through 12 in Qatar. Several factors, drawn from the research literature and overarching goals of the project, were used to investigate whether, and to what extent, Qatari schools and student characteristics influenced their attitudes toward science and associated constructs.

Brief overview of attitudes toward science research

Researchers have consistently and emphatically emphasized the importance of promoting favorable attitudes toward science, scientists, and science learning among precollege students as a precursor to bolstering the health of the scientific education pipeline (Osborne, Simon, & Collins, 2003; Tytler & Osborne, 2012). The American Association for the Advancement of Science (AAAS), in *Science for All Americans* (1990), contended that

students enter elementary school with a spontaneous interest in nature, and many emerge from school viewing science as too dull to interest them and too hard to learn. School science is frequently described as irrelevant, boring, and difficult to learn in comparison with other subjects. Indeed, remarkably concordant descriptions of school science have been discerned across Sweden, England, and Australia (see Lyons, 2006). From this depiction it should come as no surprise that researchers have paid attention to students' attitudes toward science because of an underlying hypothesis that attitudes help to steer school performance and career choice (e.g. Cannon & Simpson, 1985; Germann, 1988; Wyer, 2003). Concerns about the negative consequences that school science may have in detouring students are well founded considering that recent evidence (e.g. Sjøberg & Schreiner, 2010) reveals students' comparatively higher attitudes toward science in society, or world science.[1]

In general, attitudes are defined as a predisposition to respond positively or negatively to things, people, places, or ideas. Attitude contains affective, cognitive, and behavioral components (Simpson, Koballa, Oliver, & Crawley, 1994). Researchers, at one time or another, have used attitudes toward science to describe (a) attitudes toward science and scientists; (b) attitudes toward school science; (c) enjoyment of science learning experiences; (d) interests in science and science-related activities; and (e) intentions to pursue a career in science or science-related work (Tytler & Osborne, 2012). Koballa and Crawley summarize that attitudes toward science refer to whether a person likes or dislikes science, or has 'a positive or negative feeling about science' (p. 223). Extant studies have examined the relationship between precollege students' attitudes and their perceived utility of science (e.g. Hasan, 1985), as well as their interest, inclinations, and/or intentions to pursue additional studies in science (e.g. Crawley & Coe, 1990; Farenga & Joyce, 1998). Moreover, positive attitudes toward science have been found to motivate student interest in science education (Koballa, 1988), and science-related careers (Carey & Shavelson, 1988; Keeves, 1975; Norwich & Duncan, 1990).

Related to the situation in Qatar, the literature provides specific insight into how attitudes toward science, student interest in pursuing science, and their perceived utility or usefulness of science can impact educational outcomes and future career choices. Osborne et al. (2003), citing Shrigley (1990), state that attitude and ability scores can be expected to correlate moderately. From a meta-analysis of 43 studies, including 638,333 students from 21 countries with grade levels ranging from kindergarten through college, the correlation between science attitude and achievement was consistently significant, albeit small (0.2–0.3), for students in 6th through 10th grades (Willson, 1983). Willson goes on to explain that this evidence has been sufficient to gain general acceptance that successful achievement in science will result in positive attitudes toward science and that positive attitudes toward science contribute to student achievement. Of concern, however, are the many studies that have indicated students' attitudes toward science decline as they move from elementary school to middle school to high school (Francis & Greer, 1999; Greenfield, 1997; Koballa, 1995; Murphy, Ambusaidi, & Beggs, 2006; Murphy & Beggs, 2003).

Variables associated with attitudes toward science

Over the years, science educators have identified many variables influencing attitudes toward science (Gardner, 1975; Koballa, 1995; Osborne et al., 2003; Schibeci, 1984).

In addition to the previously outlined issues related to grade level, reviews by Gardner (1975) and Schibeci (1984) identified the following variables related to students' attitudes: gender, socioeconomic status (SES), and cultural background, as well as exposure to teaching strategies and curriculum materials.

Gender and culture. Gardner (1975) claimed that gender is likely the most crucial variable related to student attitudes toward science, and Schibeci (1984) suggested that of all the variables, gender has generally been shown to have a consistent influence. The nature and extent of this influence, nonetheless, have been contradicted by multiple studies. While it should not be taken for granted that pupils have the same preferences and needs just because they have the same gender (Sinnes & Løken, 2014), many early studies reported that boys consistently held more positive attitudes toward science than girls (Simpson & Oliver, 1985; Weinburgh, 1995). More recent studies have stated that girls were more positive in their attitudes (Boone, 1997; Murphy & Beggs, 2003), and that observed differences between the number of women and men participating in S&E fields are the result of personal-professional choices (Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005; Sinnes & Løken, 2014). Pertinent to the discussion of students' attitudes toward science in Qatar is Steinkamp's (1982) examination of students from various countries regarding variables related to gender differences in attitudes toward science. He reported that relatively larger differences in science attitudes in favor of boys occurred in developed countries, especially Japan, Australia/New Zealand, Sweden, and the USA. Israeli girls were an exception, however, with more positive attitudes toward science compared with boys. Steinkamp went on to argue that variations in the magnitude and direction of differences in boys' and girls' attitudes toward science across countries suggest that there may be a cultural explanation for gender differences in attitudes toward science. Further compounding the issue, Marsh et al. (2013) noted that the influence of gender differs as it relates to affect variables, including subject value, depending on classroom setting (i.e. single gender vs. coeducational setting).

SES. Previous works involving students from other countries (e.g. Lam & Lau, 2014) have maintained that SES plays an important role in shaping students' science achievement and attitudes. One of the challenges of making comparisons between Qatar and other contexts, and thus reiterating the importance of study as its own entity, is that sometimes parent education, occupation, and SES among families living in Qatar do not relate in a typical manner. What can be said is that the average income of nationals is significantly higher than the average income of expatriates. Also, the level of education among Non-Qatari Arab expatriates is generally higher than the levels of education among nationals (Abu-Hilal, 2001).

Teaching strategies and curriculum materials. It has been long established that the quality of teaching of school science is a significant determinant of students' attitudes toward science (Osborne et al., 2003). In this context, Woolnough (1994, as cited in Osborne et al., 2003) argued that national standards or national curricula might work to restrict the quality of science teaching in classrooms. One recommendation Woolnough makes for preserving good science teaching is that teachers should teach what they feel comfortable with, noting in his study that teachers were happiest and most enthusiastic when teaching their specialist subjects. To this point, one of the major problems under the previous education structure in Qatar was a deficit in quality teachers, often to the extent that teachers were frequently required to teach outside their area of expertise (Brewer et al., 2007).

Methods

Instrument

Participants completed the 'Arabic Speaking Students' Attitudes toward Science Survey' (ASSASS, which transliterates into 'foundation' in Arabic) that was specifically designed to address the aforementioned aims of QIAS. A thorough review of the literature related to measuring precollege students' attitudes toward science did not produce any instruments that were specifically developed, and rigorously validated, for the purpose of assessing this construct among Arabic-speaking students across a wide range of grade levels that could be used in the QIAS project. Moreover, this review converged on a set of problems among nearly all of the existing (English language) instruments that limited their applicability for cross-sectional study designs. For example, many extant instruments were designed to assess student interests and attitudes within specific grades or grade bands, rather than across the elementary, middle, and high school grades. Thus, a first major undertaking of the QIAS project was the development of an instrument that would be appropriate for the aims of the project, could collect responses from students across a range of grades, and was anchored in a robust theoretical framework (Abd-El-Khalick, Summers, Said, Wang, & Culbertson, 2015).

The finalized ASSASS instrument (Abd-El-Khalick et al., 2015) comprised 32 statements focused on students' attitudes toward science (e.g. 'I really like science'), experiences with school science (e.g. 'We do a lot of interesting activities in science class'), interest in studying science (e.g. 'I will study science if I get into a university'), intentions to pursue scientific careers (e.g. 'I will become a scientist in the future'), and views on the usefulness of science (e.g. 'We live in a better world because of science'), as well as their own perceptions of ability in school science (e.g. 'I usually give up when I do not understand a science concept'). Using a 5-point Likert scale, each statement asked students to indicate a degree of agreement or preference with a number that ranged from '1' (i.e. strong disagreement or low preference) to '5' (i.e. strong agreement or high preference), with a rating of '3' indicating that students were not sure about their choice or preference. The instrument also contained a number of questions to solicit background and demographic information from students. To be accessible to all students in Qatar—where the population includes Qatari Arabs, Non-Qatari Arabs, as well as Non-Arab residents—the ASSASS instrument was made available in both English and Modern Standard Arabic, the official language of teaching and learning in Qatar and Arab nations.

The validity of the ASSASS instrument. The validation of the ASSASS proceeded in three phases. First, a 10-member international, expert review panel helped establish the face validity of an initial pool of 60 ASSASS items, which comprised items derived from several extant attitude-toward-science instruments, as well as items developed by the authors. Second, the initial pool of items was piloted with a sample of 395 Qatari students from the target schools and grade levels. Finally, statistical validation of the instrument and its underlying structure were based on data derived from a national sample of 3027 students in Qatar (Abd-El-Khalick et al., 2015). These stages of development and validation were crucial as many instrument developers have only used a panel of judges to evaluate their instruments for validity. This aspect should be a part of the validation process, but 'panel validity' alone is not sufficient (DeVellis, 2003) and needs to be accompanied by psychometric or objective evidence as suggested by Munby (1997).

Furthermore, analysis of the large-scale administration data led to the refinement of a five-factor model, which included the following factors: attitudes toward science and science learning, unfavorable outlook toward science, control beliefs, behavioral beliefs about the benefits of science, and intentions to pursue or engage in science in the future. The ASSASS instrument final model, obtained through confirmatory factor analysis (CFA) and subsequent refinement, had a close fit as judged by a Standardized Root Mean Square Residual (SRMR) of 0.037, a comparative fit index (CFI) of 0.937, and a Tucker–Lewis index (TLI) of 0.931 (Hu & Bentler, 1999). Abd-El-Khalick et al. (2015) report that all five factors demonstrated robust reliability measures with good to excellent scale reliabilities, estimated based on the results of CFA, ranging from 0.61 to 0.87. Factor covariances for the finalized 32-item instrument are presented in Table 1. The five ASSASS factors or sub-scales are as follows: (1) 'Attitude,' which comprised student attitudes toward science (e.g. 'I really like science') and toward school science learning (e.g. 'I really enjoy science lessons'); (2) 'Control beliefs,' which addressed respondents' perceived ability and self-efficacy toward science learning (e.g. 'I am sure I can do well on science tests'); (3) 'Behavioral beliefs,' which pertain to beliefs about the consequences of engaging with science, including becoming a scientist (e.g. 'Scientists do not have enough time for fun') and beliefs about the social and personal utility of science (e.g. 'We live in a better world because of science' and 'Knowing science can help me make better choices about my health'); (4) 'Unfavorable outlook' on science, which represented an amalgam of negative dispositions toward school science, perceived ability to learn science, and the personal and societal utility and contributions of science; and (5) 'Intention,' which probed respondents' intentions to pursue additional science studies (e.g. 'I will study science if I get into a university') or careers in science (e.g. 'I will become a scientist in the future') (see Abd-El-Khalick et al., 2015 for a detailed discussion).

Participants: a nationally representative sample

The Education for a New Era reform initiative, along with the curricular changes noted earlier, was accompanied by a reorganization of Qatari schools. Before this initiative was enacted, schools in Qatar could be categorized as follows: (1) Ministry of Education schools; (2) Independent schools; (3) International and community schools; and (4) Private schools. Starting in 2004, according to the mandate, new government-funded schools were established but not operated by the Ministry of Education (Zellman et al., 2009). These schools were first labeled as semi-independent to indicate that, while funded by the state, independent operators ran these schools. Eventually, with the completion of the reform process in the 2010–2011 academic year, both semi-independent and independent schools were then labeled as independent. Given that data collection with the ASSASS was undertaken only a year later (in the Spring of 2012), the semi-

Table 1. ASSASS instrument factor covariances.

Factor	Attitudes	Unfavorable outlook	Control beliefs	Behavioral beliefs
Unfavorable outlook	0.41			
Control beliefs	0.74	0.44		
Behavioral beliefs	0.79	0.42	0.76	
Intention	0.84	0.37	0.72	0.75

independent and independent labels were maintained throughout data analysis because the teaching and learning cultures that typified these types of schools over many years were likely to carry forward for a number of years beyond the arbitrary date of reclassifying or renaming 'semi-independent' schools as 'independent.'

To help explain the preceding depiction of recent educational reforms, it should prove useful to outline the different types of schools in Qatar as they stood at the time of data collection (Table 2). During the 2011–2012 school year, the proportions of Qatari students were 59%, 30%, and 31% for semi- and independent schools, international and community schools, and Private Arabic schools, respectively. For Non-Qatari Arabs the proportions are 34%, 33%, and 63% across the school types listed (Supreme Education Council Evaluation Institute, 2012). Independent and semi-independent schools are publicly funded, privately run schools similar to charter schools in other nations. Arab children whose parents work in the public sector, government employees for example, are eligible to attend publicly funded schools (Abu-Hilal, 2001). Semi-independent and independent schools, as noted above, are distinguished only by semi-independent schools being more recently operated by Qatar's Ministry of Education. Otherwise, semi- and independent schools are similar in operation, language of science instruction, and curriculum, the Qatar national curriculum. The remaining types of schools in Qatar, Community, International, and Private Arabic schools, are all private options for children whose parents work in the private sector, but selectively admit students based on certain characteristics (e.g. mother tongue or national affiliation). A Community school offers curriculum from a country other than Qatar, generally for the children of a specific group of expatriates living in Qatar (e.g. Indians, British, Pakistani, or Americans) and are sponsored by the embassy of the relevant country (Zellman et al., 2009). International schools follow the curriculum of a foreign country or a general international curriculum, and enroll expatriate, as well as Qatari and Non-Qatari Arab, students (Zellman et al., 2009). Private Arabic schools follow the Qatar national curriculum and mainly cater to the large Non-Qatari Arab communities residing in Qatar.

As part of the QIAS project, the ASSASS was administered to a nationally representative sample of students in grades 3 through 12 (Abd-El-Khalick et al., 2015). In order to draw a nationally representative sample, all schools registered with the Qatari Ministry of Education were contacted to request information about enrollments, including the number of class sections per grade level. A total of 194 schools (65%) provided the requested information, which was used to generate a database of 3241 class sections comprising all sections in grades 3 through 12 across all respondent schools and school types (independent, semi-independent, Private Arabic, International, and Community). Next, four sections per grade level (in grades 3 through 12) and school type were randomly selected from this database, resulting in a sample of 200 class sections. For this study a subsample of survey responses were analyzed, focusing on those responses collected from Qatari and Non-Qatari Arabs. Additionally, to help control for differences among respondents on the basis of culture, selection of the analytical was limited to those students who elected to complete the Arabic version of the ASSASS (see Table 3). A total of 1978 respondents completed the survey in Arabic. An analytic sample of 1850 students (41.9% male, 55.5% female, 2.6% unreported) was included in this subsample and comprised 45.9% Qatari and 46.2% Non-Qatari Arabs students (7.9% unreported).

Table 2. Description of precollege school settings in Qatar as of Spring 2012.

School type	Description	Student composition	Curriculum	Language of instruction
Independent	Publicly funded, with some autonomy. Follow curriculum prescribed by the Supreme Education Council. Lessons are taught in Arabic, with English, math, Islamic Studies, and science all compulsory subjects.	Mainly Qatari	Qatar National Curriculum	Arabic for core subjects except science. Science instruction in English.[a]
Semi-independent	Publicly funded, privately run schools that were until recently operated by the Ministry of Education. Adheres to the curriculum prescribed by the Supreme Education Council with lessons taught in Arabic, with English, math, Islamic Studies, and science all compulsory subjects.	Mainly Qatari	Qatar National Curriculum	Arabic for core subjects except science. Science instruction in English.[a]
Community	Privately funded, privately run schools sponsored by the embassy of the affiliated country. The curricula taught in these schools usually reflect that of its affiliated home country.	Mainly Non-Qatari Arabs and Non-Arabs	Depends on the national affiliation	Varies
International	Privately funded, privately run schools sponsored by the embassy of the affiliated country. International schools follow the curriculum of a foreign country or a general international curriculum.	Qatari, Non-Qatari Arabs, and Non-Arabs	May depend on national affiliation or follow a general international curriculum	Varies
Private Arabic	Privately funded, privately run schools that follow the Qatar national curriculum. Mainly cater to the large Non-Qatari Arab communities residing in Qatar whose parents work in private sectors and are not eligible in government-funded schools.	Mainly Non-Qatari Arabs	Qatar National Curriculum	Varies

[a]Since 2014 Arabic has been the official language of science instruction with a focus on English terminology.

Data analysis

Descriptive analyses of students' responses were first used to generate mean scores and associated statistics for each of the five factors of the ASSASS instrument. Next, inferential analyses were used to produce a multiple indicators multiple causes (MIMIC) model, a special type of structural equation model, that relates CFA-based results with observed indicators. This computation was done in *Mplus* using the maximum likelihood robust (MLR) estimator. MLR is a rescaling-based estimator that can deal with non-normality in data with standard error (SE) and chi-square tests that are robust to non-normality. The use of this estimator is appropriate given that the present data set was not normally distributed, and also because MLR is capable of handling missing data (i.e. missing student responses to the ASSASS instrument).

Construction of the MIMIC models is a two-step process that involves (1) computing the measurement model and (2) establishing an adequate structural model. First, computation of the measurement model was completed using CFA in a manner similar to the completion of CFA performed as part of the validation process for the ASSASS instrument (Abd-El-Khalick et al., 2015). Figure 1 presents the five factors of the ASSASS with their constituent items, factor loadings, and residuals.

To complete the second step in the MIMIC modeling process, observed indicators were selected for inclusion into the model. Based on our review of the literature, as well as the focus of the QIAS project, the indicators selected for examination during the MIMIC modeling process included student age, gender, nationality, as well as

Table 3. Analytic sample of ASSASS respondents ($N = 1850$).

	Students									
	Grade	Age	Number		Sex					
					Male		Female		Not reported	
School			*n*	%[a]	*n*	%[b]	*n*	%[b]	*n*	%[b]
School level										
Primary	3	8.9	211	11.4	98	46.5	103	48.8	10	4.7
	4	9.8	195	10.5	74	38.0	118	60.5	3	1.5
	5	10.9	166	9.0	52	31.3	108	65.1	6	3.6
	6	11.6	195	10.5	67	34.4	120	61.5	8	4.1
Total	–	10.2	767	41.4	291	38.0	449	58.5	27	3.5
Preparatory	7	12.3	241	13.0	90	37.4	148	61.4	3	1.2
	8	13.3	203	11.0	133	65.5	67	33.0	3	1.5
	9	14.6	161	8.7	87	54.0	73	45.4	1	0.6
Total	–	13.2	605	32.7	310	51.2	288	47.6	7	1.2
Secondary	10	15.8	159	8.6	71	44.7	80	50.3	8	5.0
	11	16.5	123	6.7	45	36.6	74	60.2	4	3.2
	12	17.0	196	10.6	58	29.6	136	69.4	2	1.0
Total	–	16.5	478	25.9	174	36.4	290	60.7	14	2.9
Grand total	–	12.8	1850	100.0	775	41.9	1027	55.5	48	2.6
School type										
Independent			636	34.4	262	41.2	368	57.9	6	0.9
Semi-independent			628	33.9	159	25.3	450	71.7	19	3.0
International			20	1.1	16	80.0	0	0.0	4	20.0
Community			237	12.8	92	38.8	140	59.1	5	2.1
Private Arabic			329	17.8	246	74.8	69	21.0	14	4.2
Grand total			1850	100.0	775	41.9	1027	55.5	48	2.6

[a]Percent of grand total.
[b]Percent of corresponding grade or school level.

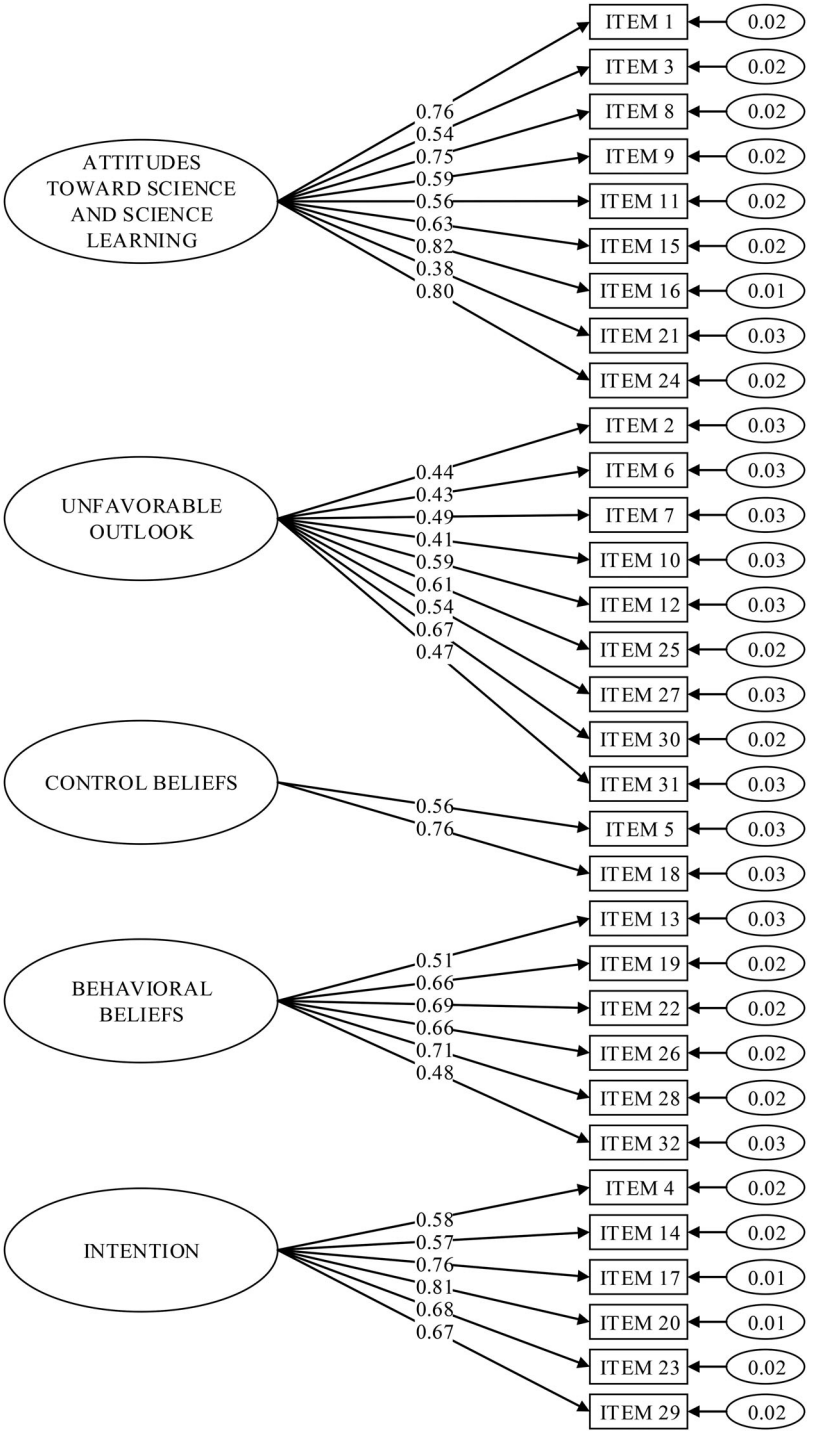

Figure 1. Measurement model of the ASSASS instrument, including item loadings and residuals, from CFA.

school type. Age was treated as continuous, while the other indicators examined—gender, nationality, and school type—were all treated as categorical. References for the categorical indicators examined were set to male for gender, Non-Qatar Arab for nationality, and the independent school type. Note that SES and class gender, a group-level variable, are absent from the models produced. Exploratory analyses revealed that these indicators were not useful in meaningfully characterizing the student responses collected.

Results

Attitudes toward science: descriptive statistics

Students' mean scores, disaggregated by age and gender, suggested that, overall, students' attitude and intention scores declined with age (Figure 2). By comparison, scores on the unfavorable outlook, behavioral and control beliefs factors, tended to be much more stable with increasing age. It is notable that mean scores on the behavior and control factors remain around 4 on the 5-point Likert scale throughout grades 3 through 12. Also it is important to note that while a decreasing pattern in students' mean attitude factor scores is observed with respect to age, a similar pattern on the unfavorable outlook factor is not evident. It should be noted that in the case of the unfavorable outlook factor, respondents' scores have been reverse coded such that a higher score reflects a more favorable stance toward science.

Figure 2 also distinguishes students' mean ASSASS scores by gender and suggests that no consistent effect existed on any of the five factors. The trend lines for each of the five factors, representing the scores of males and females, are entangled. In some cases, no difference can be discerned (e.g. attitude factor), while in others the difference is temporary with respect to age (e.g. control factor) with no clear pattern. On the other hand, comparing the responses of Qatari and Non-Qatari Arabs yielded a clear pattern, suggesting a difference based on the nationality of respondents that favors Non-Qatari Arabs (Figure 3). In fact, examining students' mean factor scores by age and nationality revealed that Qatari students' attitude and intention scores descended to neutral, with mean scores near 3, by age 16. By comparison Non-Qatari Arabs appear to have a nearly 0.5-point advantage on the same factors at age 16, a pattern that continues through age 18. A similar pattern is observed for the other three factors, with Non-Qatari Arabs reporting consistently higher mean scores.

Comparison of computed MIMIC models

A total of two MIMIC models were computed and are presented below. For each model the fit statistics and standardized coefficients are discussed. Drawing on the research literature and goals of the QIAS project, the first model included respondents' age, gender, and nationality. The second, alternate, model added an indicator for school type. Aside from being an important research question related to the influence of Qatari schools, the addition of the school type indicator is notable because it helps to explain variation within groups of students rather than adding another individual student characteristic. The presentation of the simpler model first, without school type,

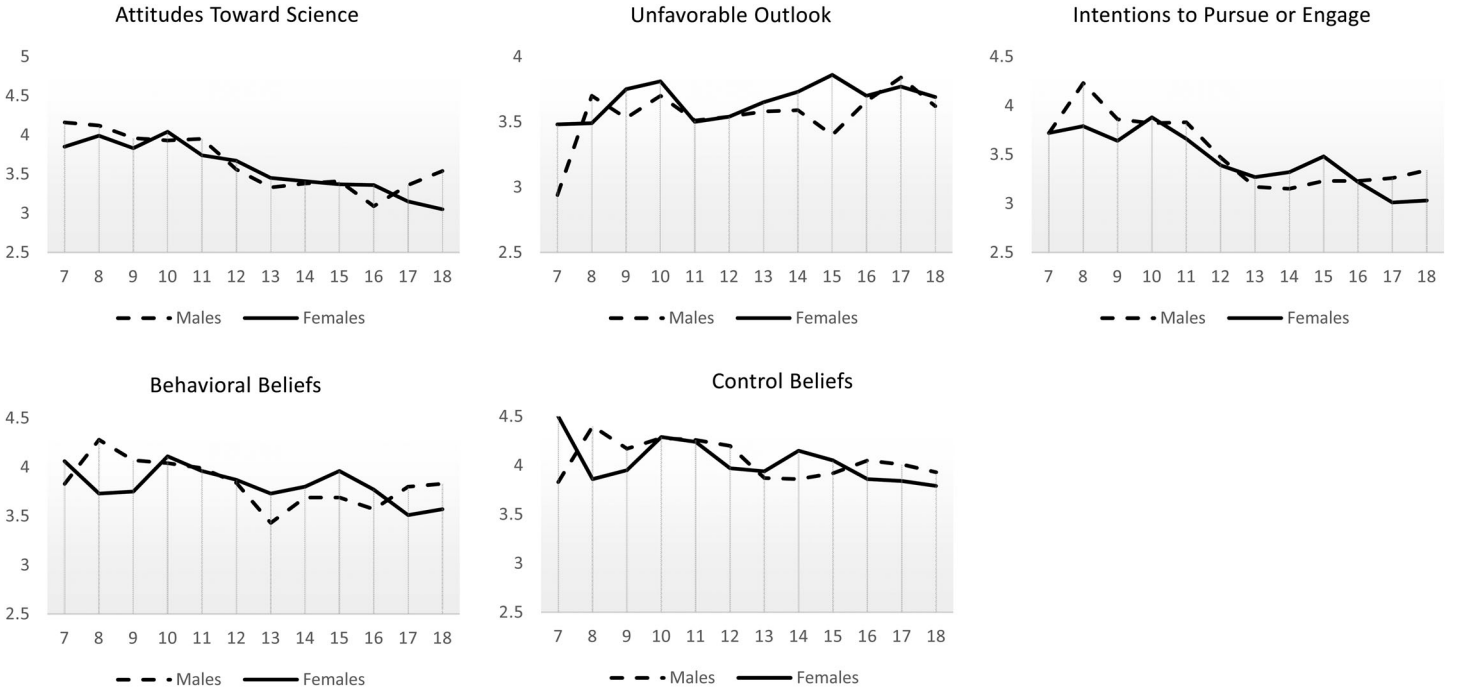

Figure 2. Mean factor scores of Qatari students by gender (gender was not reported by all students) and age (students who did not report their age, or were older than 18, were omitted).

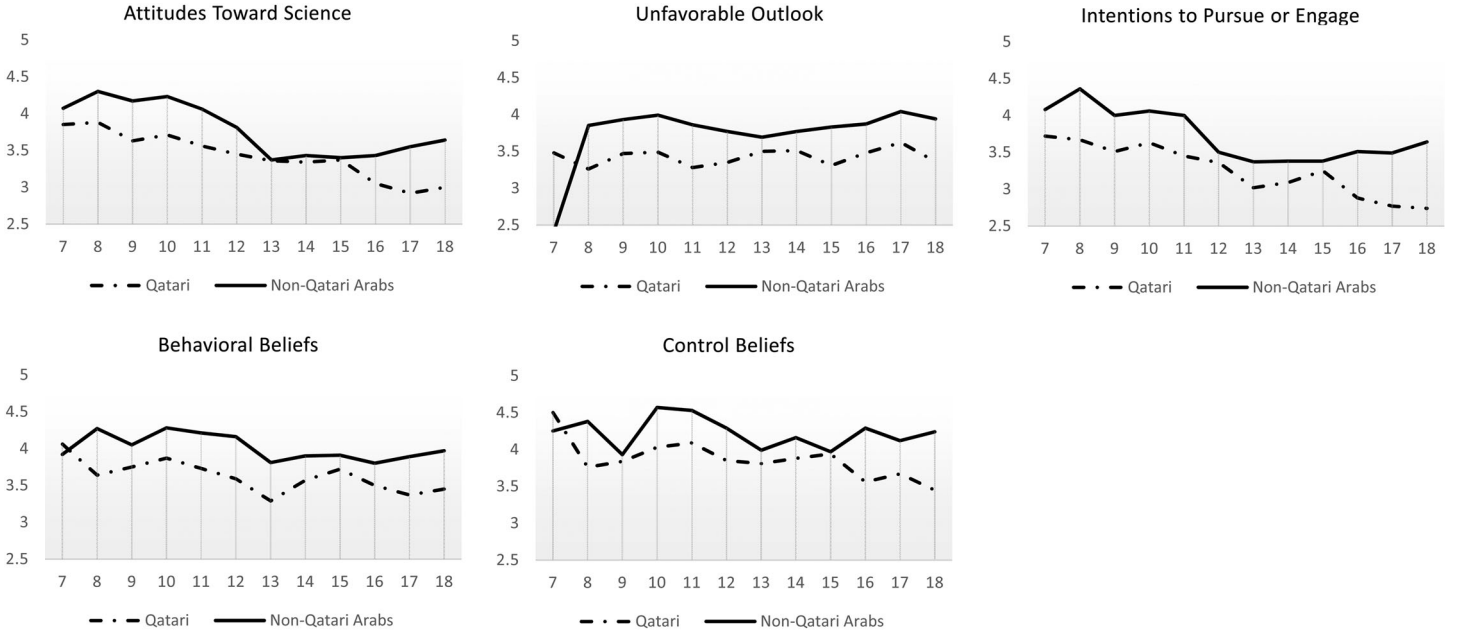

Figure 3. Mean factor scores of students by age and nationality.
Note: Factor scores are organized by nationality; Qatari and Non-Qatari Arab students, respectively.

is appropriate given that this model is nested within the second MIMIC model. The two models presented are compared using a likelihood ratio test. Due to the fact that the difference in chi-squares of the two models, computed using MLR, does not follow chi-square distributions, a scaled difference using scaling correction factor was used for the likelihood ratio test.

Preliminary model. The preliminary MIMIC model, which included indicators for age, gender, and nationality, had a close fit (Browne & Cudeck, 1993; Byrne, 1998) with a root mean square error of approximation (RMSEA) of 0.032, an SRMR of 0.038 (values <0.05 indicate close approximate fit), a CFI of 0.938 (values >0.9 indicate reasonably good fit), and a TLI of 0.932 (values >0.9 indicate reasonably good fit) (see Hu & Bentler, 1999). Significant standardized coefficients for the preliminary MIMIC model, listed in Table 4, show that the age indicator was significant for four of the five ASSASS factors ($p < .001$), with the exception of unfavorable outlook. Negative coefficients for these factors indicate that students' mean scores declined with age. It is important to note that as students' age increased, unfavorable outlook did not become more severe. Additionally, the nationality indicator was significant ($p < .001$) on all factors favoring Non-Qatari Arabs. Finally, consistent with the absence of a clear pattern noted in the descriptive statistics section, the preliminary MIMIC model did not contain significant coefficients on any of the five factors for the gender indicator.

Alternate model. The alternate MIMIC model expanded on the preliminary model that included age, gender, and nationality indicators by adding the school type indicator. The alternate model, similar to the preliminary model, had a close statistical fit with an RMSEA of 0.031, an SRMR of 0.035, a CFI of 0.935, and a TLI of 0.927. Significant standardized coefficients from the nested portion of alternate MIMIC model were consistent, and comparable in magnitude, with those from the preliminary model (Table 5). Age was significant ($p < .001$) on four of the five factors, all except unfavorable outlook, and illustrated decreasing mean factor scores with an increase in age. The alternate model also highlighted the nationality indicator as being significant on all five factors, again favoring Non-Qatari Arabs. Considering the various types of Qatari schools examined, it should be noted that all school types contained both Qatari and Non-Qatari Arab respondents. The school type indicator highlighted significantly lower coefficients ($p < .001$) for semi-independent and Private Arabic schools, on three and four of the ASSASS factors, respectively. Conversely, compared to the referenced independent school type, community schools only had a significantly lower coefficient ($p < .001$) on a single factor, the control factor, and no significant differences were detected for International schools.

Given the similarity of the preliminary model and resultant standardized coefficients with the nested portion of the alternate model, a scaled likelihood ratio test was conducted to ascertain the necessity of the school type indicator in the model. The likelihood ratio test supported the inclusion of the school type indicator and confirmed that it significantly ($p < .001$) improved the MIMIC modeling of students' responses to the Arabic ASSASS. Figure 4 illustrates the finalized model with standardized coefficients of all four indicators on the left linked to the five ASSASS factors, or sub-scales, on the right. (Note that vertical arrows indicate error.)

Table 4. Standardized effect estimates for the preliminary MIMIC model (age, gender, and nationality).

	Age		Gender		Nationality	
	Estimate	SE	Estimate	SE	Estimate	SE
Attitude	−0.27*	0.03	0.01	0.04	−0.21*	0.03
Unfavorable	0.02	0.03	−0.03	0.03	−0.32*	0.03
Control	−0.15*	0.03	0.01	0.04	−0.26*	0.03
Behavior	−0.15*	0.03	−0.01	0.04	−0.30*	0.03
Intention	−0.26*	0.03	0.00	0.03	−0.23*	0.03

*Significant to the $p < .001$ level.

Table 5. Standardized effect estimates for the final MIMIC model (age, gender, nationality, and school type).

	Age		Gender		Nationality		School type							
							Semi-independent		Private Arabic		Community		International	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Attitude	−0.27*	0.03	0.02	0.04	−0.23*	0.03	−0.04	0.03	−0.09*	0.03	−0.02	0.03	0.02	0.03
Unfavorable	0.02	0.03	−0.05	0.03	−0.31*	0.03	−0.09*	0.03	−0.04	0.03	0.04	0.04	−0.05	0.04
Control	−0.15*	0.03	0.00	0.04	−0.32*	0.04	−0.12*	0.04	−0.11*	0.04	−0.10*	0.04	−0.04	0.04
Behavior	−0.15*	0.03	−0.01	0.04	−0.29*	0.03	−0.11*	0.04	−0.08*	0.04	0.05	0.03	0.03	0.03
Intention	−0.25*	0.03	0.01	0.03	−0.26*	0.03	−0.04	0.03	−0.09*	−0.03	−0.04	0.04	0.03	0.03

*Significant to the $p < .001$ level.

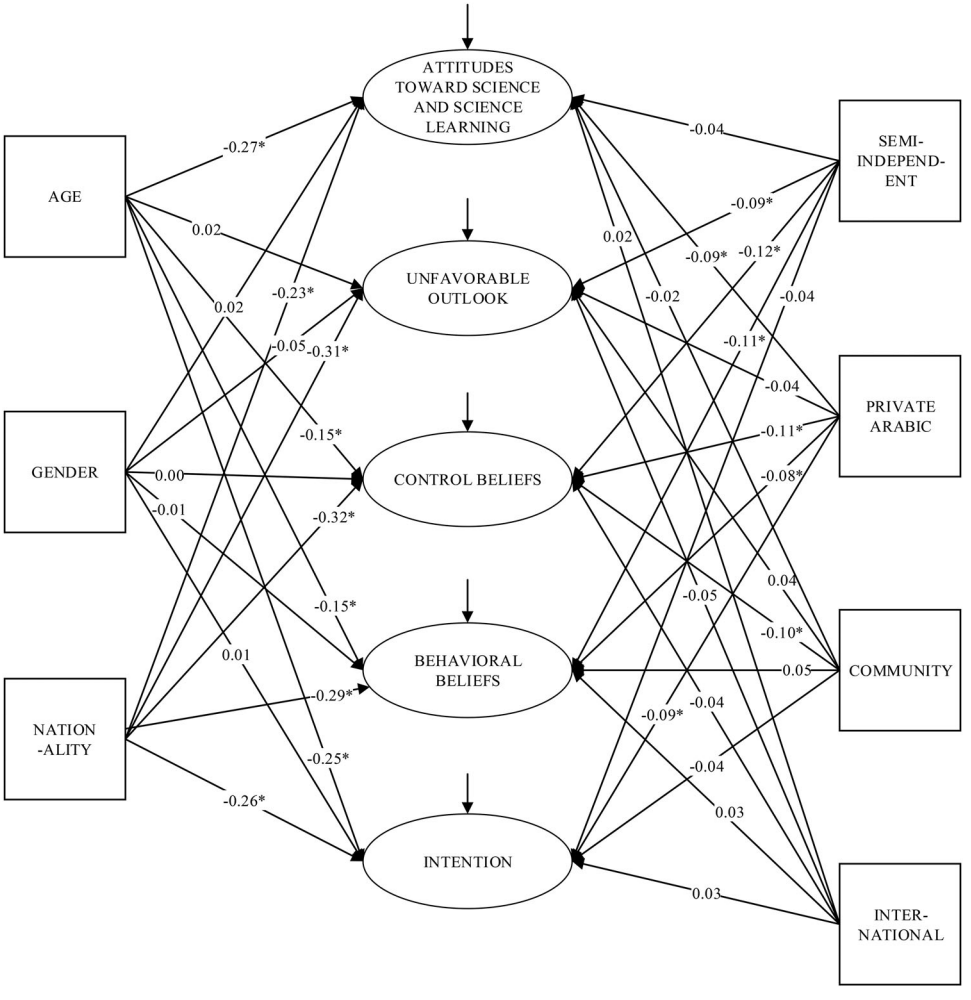

Figure 4. Final model linking student age, gender, nationality, and school type indicators to the five factors of the ASSASS instrument. *Significant to the $p < .001$ level.

Discussion

The final MIMIC model contained indicators for age, gender, nationality, and school type to aid in the characterization of students' responses to the Arabic ASSASS. Of the indicators included in this model, age and gender have been examined extensively by past research in relation to students' attitudes toward science. Consistent with prior works (Francis & Greer, 1999; Murphy et al., 2006), findings from the present study depict a declining pattern in students' attitudes toward science, and related factors, as student age increases. Indeed, on four of the five ASSASS sub-scales (namely, attitudes toward science and science learning, control beliefs, behavioral beliefs, and intentions to pursue science in the future), significant negative coefficients were evident with respect to the age indicator. Collectively, these factors speak to Qatari students' decreased interest in studying science and perceived ability in science, as well as diminished beliefs about the utility and importance of science leading to weakening intentions of engaging science in the future.

Lyons (2006) linked the observed declines in students' science interest in several nations around the globe to research, which showed that students grow more disengaged in science classrooms as they advance from primary to secondary school. This characterization seems to apply well in the case of Qatar. Several of the concerns that fueled the Education for a new Era reform spoke directly to inadequate curriculum and standards, coupled with a low-rigor experience in the classroom. Brewer et al. (2007) reported that under this system, students had few opportunities to develop or display their talents and abilities, and teachers were unable to take the time to challenge bored students or help those who needed extra attention. Still, in spite of the innovations introduced by the 'Education for a New Era' reform initiative (Zellman et al., 2009), a recent poll of Qatari educators suggests that the changes enacted have been insufficient to shift Qatari instruction away from a lecture-dominated experience and continue to place little emphasis on hands-on science learning (Said & Friesen, 2013). In addition to the perceived nature of the science curriculum by Qatari teachers, Said and Friesen also noted that 40 of 62 teachers surveyed highlighted the difficulty of the science content as a detracting element. Moreover, efforts to generate student interest in science by promoting practical aspects of science instruction, such as hands-on inquiry, have not been fruitful because existing policy prioritizes content-focused assessments (Supreme Education Council Evaluation Institute, 2005).

Gender, the second indicator included in the final MIMIC model that has been explored in prior literature, was found to have no significant effect on any of the five factors in the present study. The absence of a gender effect is rather surprising and, more importantly, quite promising because many studies in western and European contexts have previously drawn attention to discrepancies in students' reported attitudes toward science, favoring male students, as well as similar concerns about differential science achievement (e.g. Keeves & Kotte, 1996). Some recent works have challenged this perception (e.g. Boone, 1997; Murphy & Beggs, 2003), but other authors (e.g. Simpson & Oliver, 1990) have argued that other closely held convictions, such as achievement motivation, have driven females to succeed in science. For girls growing up in Qatar, it is possible that furthering their education might afford them future opportunities that they would not otherwise have in their culture. Additionally, as suggested by Steinkamp (1982), individuals in areas that have developing knowledge economies, such as Qatar, may hold cultural values that supersede gender-based preferences. Similarly, culture may also help explain the differences found between Qatari and Non-Qatari Arab respondents. Among the latter is that ascending the socioeconomic scale is a major motivation for most, if not all, Non-Qatari Arab families who move to Qatar seeking economic opportunities.

The third indicator included in the final MIMIC model, nationality, revealed that Non-Qatari Arabs were favored on all five of the ASSASS sub-scales. The descriptive statistics computed support the claim that Qatari students, more than Non-Qatari Arabs, do not carry the same regard for science and science learning, do not see science as being as useful in their daily lives (behavioral beliefs), are less confident in their ability to learn science (i.e. control beliefs), and are not as inclined to pursue or engage in future science endeavors. The comparison between Qatari and Non-Qatari Arabs is particularly interesting on the unfavorable outlook ASSASS factor. This factor includes a variety of issues extending from students perceived ability in science (e.g. I cannot understand science even if I try hard) and tenacity for learning science (e.g. I usually give up when

I do not understand a science concept), their perception of school science (e.g. Science lessons are a waste of time), and their view of the importance of learning science (e.g. Learning science is not important for my future success). Participants unfavorable outlook toward science did not differ by age, but showed differences by nationality. Specifically, Non-Qatari Arabs outperformed their Qatari counterparts on this scale. Given the interconnectedness of this particular sub-scale, it may be the case that once students have formed these perspectives, they are somewhat more enduring and do not change with increasing age. These findings might be reflective of the differing levels of parental education, which is generally higher among Non-Qatari Arabs (Abu-Hilal, 2001). Educational values held by Non-Qatari Arab families may also encourage them to make the best of their residency in Qatar and benefit from the recent developments to the Qatari educational system.

Examination of responses to the Arabic ASSASS in the present study on the basis of school type, the fourth indicator included in the final MIMIC model, suggested that students are differentially influenced by their learning environment. It is important to note that all school types, including the independent school type, which acted as the reference, enrolled both Qatari and Non-Qatari Arab respondents. Independent schools seemed to relatively foster the most desirable stances on the factors assessed by the ASSASS. While the International school type performed comparably to independent schools, it is important to note that the sample size is small and may not yield meaningful inferences for all International schools in Qatar. In contrast the other school types—Private Arabic, semi-independent, and Community schools, all showed significant negative coefficients on one or more factors. Considering school type as a proxy for quality science instruction in Qatar, it is important to consider that students attending independent schools may have benefited more from established educational settings compared to those attending semi-independent schools that are only recently completing the transition. The dismal performance of Private Arabic schools, with negative coefficients on four of the ASSASS sub-scales, is very curious. Private Arabic schools cater to the large Arab expatriate communities residing in Qatar, and it may be the case that these schools vary on an individual level to a greater extent than independent or semi-independent schools. Still, the present study suggests that Private Arabic and other school types common to Qatar can negatively influence students' preferences about science in a way that is distinct from their nationality.

Conclusions

The responses of Qatari students from grades 3 through 12 indicate that students' attitudes toward science, and associated factors, deteriorate with age. The observed decline in students' science-related preferences as they progress through Qatari school is concerning, even more so because student nationality and the type of school they attend can further confound their acquired preferences. Results from the present study are compatible with vetted concerns regarding Qatari student enrollment and involvement in the sciences at the post-secondary level, with Qatari students harboring more negative attitudes toward science compared to Non-Qatari Arabs. Other findings from this study, such as the absence of a gender effect, raise questions for future work about the intersection of gender, culture, and language.

Note

1. Hereafter, attitudes toward science is used by the authors to refer to school science as discussed in the context of the present study.

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