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Development and Large-Scale Validation of an Instrument to Assess Arabic-Speaking Students' Attitudes Toward Science

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This study is part of a large-scale project focused on 'Qatari students' Interest in, and Attitudes toward, Science' (QIAS). QIAS aimed to gauge Qatari student attitudes toward science in grades 3–12, examine factors that impact these attitudes, and assess the relationship between student attitudes and prevailing modes of science teaching in Qatari schools. This report details the development and validation of the 'Arabic-Speaking Students' Attitudes toward Science Survey' (ASSASS), which was specifically developed for the purposes of the QIAS project. The theories of reasoned action and planned behavior (TRAPB) [Ajzen, I., & Fishbein, M. (2005). The influence of attitudes on behavior. In D. Albarracín, B. T. Johnson, & M. P. Zanna (Eds.), *The handbook of attitudes* (pp. 173–221). Mahwah, NJ: Erlbaum] guided the instrument development. Development and validation of the ASSASS proceeded in 3 phases. First, a 10-member expert panel examined an initial pool of 74 items, which were revised and consolidated into a 60-item version of the instrument. This version was piloted with 369 Qatari students from the target schools and grade levels. Analyses of pilot data resulted in a refined version of the ASSASS, which was administered to a national probability sample of 3027 participants representing all students enrolled in grades 3–12 in the various types of schools in Qatar. Of the latter, 1978 students completed the Arabic version of the instrument. Analyses supported a robust, 5-factor model for the instrument, which is consistent with the TRAPB framework. The factors were: Attitudes toward science and school science, unfavorable outlook on science, control beliefs about ability in science, behavioral beliefs about the consequences of engaging with science, and intentions to pursue science.

Keywords: *attitudes toward science; K-12; instrument development; Arabic; Qatar*

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Introduction

It is decidedly clear that 'in the 21st century, advances in science and engineering [S&E] will to a large measure determine economic growth, quality of life, and the health and security' of all nations and the planet (National Science Board [NSB], 2001, p. 7). The sciences have become integrally intertwined with the viability and sustainability of all crucial foundations of prosperous nations, ranging from health and security to the economy. While issues related to the current state and sustainability of the scientific enterprise have received increased attention within the United States and other developed nations (e.g., National Research Council, 2007; NSB, 2001; United States Department of Labor, 2007), these issues also are profoundly significant throughout the globe and, particularly, in regions that do not have strong histories of scientific production. In an increasingly globalized world, advances in S&E research are 'no longer the domain of only a small group of countries. The extent to which [S&E] is able to contribute to societal goals, [and] address global problems … relies to a high degree on global communication and cooperation' (NSB, 2001, p. 7). Simply put, forward-looking, twenty-first century nations need not only nurture and ensure healthy and sustainable research and development (R&D) in the sciences within their borders, these nations should be poised and well-prepared to meaningfully and substantially engage with—and, thus, share the benefits accruing from—scientific R&D at the global level.

Qatar, an Arab nation located on the Persian Gulf, has taken the above priorities to heart as evidenced by the launch, nearly 20 years ago, of the multi-billion dollars endowed Qatar Foundation for Education, Science and Community Development. The Qatar Foundation 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). Nonetheless, despite the availability of Qatari funding and resources, current prospects for realizing these goals in Qatar, as with other Arab nations, continue to meet 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. In addition to thin production, scientific research in Arab countries is held back by weak basic research and the almost total absence of advanced research in fields such as information technology and molecular biology. (p. 23)

The number of qualified S&E workers in all Arab countries is 371 per million citizens compared to a global rate of 979 per million. The number of Arab students enrolling in scientific disciplines in higher education is similarly low. Indeed, the World Bank (2008) reported that a mere 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 S&E (The World Bank, 2008). The UNDP (2003) report also noted that while the number of scientific

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publications (26 research papers per million people) places Arab countries within the advanced group of developing countries, it still falls way short of the production levels in developed nations (e.g. 840 in France and 1878 in Switzerland). However, UNDP (2003) suggested that 'Arab countries possess significant human capital, which under new circumstances, could serve to lead, support and sustain a knowledge renaissance centered on knowledge production' (p. 98).

This latter emphasis on the development of human capital is rightly placed because 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). 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. Unfortunately, like other Arab nations, the rather low current enrollments in scientific disciplines among college students surely is not commensurate with Qatar's goals to bolster scientific research and development, and usher the nation into the ranks of the twenty-first century knowledge production global community.

This state of affairs undoubtedly is complex and multi-faceted, but it is safe to infer that by the time they reach college or get to make decisions about 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. Research depicts a well-established relationship between these affective variables and precollege students' learning and achievement (e.g. Ainley, Hidi, & Berndorff, 2002; Hidi, 1990) especially in science (e.g. Chang & Cheng, 2008; Laukenmann et al., 2003), as well as student decisions to pursue scientific studies and career choice (e.g. Calabrese-Barton & Basu, 2007; Mason & Kahle, 1989). Researchers have consistently and vigorously 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).

In this context, the 'Qatari students' Interest in, and Attitudes toward, Science' project (QIAS, which transliterates into 'measurement' in Arabic) aimed to gauge Qatari school students' attitudes toward science and changes in these attitudes as students move across grade levels, specifically grades 3–12. In this regard, it should be noted that there is a dearth of rigorous, published research on precollege students' attitudes toward science both in Qatar and across the Arab world. Indeed, our examination of the literature identified a single published study, which examined attitudes toward science among secondary school students in Jordan (i.e. Hasan, 1985). The QIAS project also aimed to examine factors that impact student attitudes toward science, and the relationship between these attitudes and modalities of science teaching in Qatari schools.

Need for Developing a New Instrument

Central to the research efforts of the QIAS project was the identification of a paper-and-pencil instrument that would generate a valid and reliable assessment of Qatari students' attitudes toward science in grades 3–12. A thorough review of the literature revealed that while a small number of robust instruments aimed at assessing precollege students' attitudes toward science have been developed over the past four decades (see Osborne et al., 2003; Osborne, Simon, & Tytler, 2009), none of the extant instruments were adequate for our purposes. First, no instruments have been specifically designed and systematically validated for use with Arabic-speaking students. There are major issues associated with the transfer of psychometric and educational instruments developed within specific cultural contexts (mostly Western in the present case) for use in other, substantially different contexts, such as the culture(s) of the Arab world (Hambleton, Merenda, & Spielberger, 2005). It should be noted that several Arabic dialects are spoken across the Arab world. However, Modern Standard Arabic (MSA) is the official language in all 22 Arab nations with a total population of about 370 million. MSA serves as the linguistic and cultural currency that cuts across teaching, learning, and scholarship, as well as media in the Arab world. Thus, an instrument utilizing MSA would have wide applicability across Arab nations. Second, while QIAS aimed to measure student attitudes in grades 3–12, most existing instruments focus on a particular grade or school level (e.g. Hamerick & Harty, 1987; Heikkinen, 1973).

Finally, it should be noted that many researchers have raised serious doubts about a number of existing instruments that purport to measure precollege student attitudes toward science. Indeed, Peterson and Carlson (1979) stated that 'attitude research is chaotic' (p. 500), and close to four decades later these words still hold true (Osborne et al., 2009). Starting in the mid-1970s, researchers (e.g. Gardner, 1975; Munby, 1979; Pearl, 1974) have placed the blame for such disarray with inadequate instrumentation. Munby (1979) criticized the validity and credibility of instruments seeking to quantify affective outcomes in science education, claiming that existing instruments do little to 'enlist our confidence in their use' (p. 273). This trend has persisted with researchers continuing to voice concerns about measures of student attitudes in science for lacking robust evidence for validity and reliability (e.g. Krynowsky, 1988; Munby, 1983; Pearl, 1974; Ramsden, 1998). However, despite such cautioning, Osborne et al. (2009) reported that, in multiple cases, efforts to establish validity and reliability of attitude instruments in science education have been poor. In their review of instruments, Blalock et al. (2008) echoed this sentiment and identified numerous cases in which instruments failed to meet the minimum standards of modern psychometric evaluation. Many instruments, which are still in current use, were developed in the 1970s and 1980s (e.g. Fraser, 1978; Germann, 1988; Moore & Sutman, 1970; Simpson & Troost, 1982). For instance, Owen et al. (2008) demonstrated the potential for re-evaluating extant instruments by using factor analysis to refine the Simpson-Troost Attitude Questionnaire (Simpson & Troost, 1982) form 58 items under 14 sub-scales to 22 items spanning five revised dimensions. Such potential for refinement illustrates the merit and necessity of using modern psychometric analyses in attitude instrument development in science education.

Critiques of extant instruments' validity have also been extended to the item creation and/or selection processes. Munby (1982) highlighted issues associated with the overreliance on advisory panels for establishing the face validity of an instrument, a common practice in the development of several measures of attitude (e.g. Germann, 1988). Munby emphasized that the meanings attributed to the items by a panel of experts will not be the same as those attributed by respondents. Osborne et al. (2009), in an effort to circumvent such pitfalls, advocated the use of participant interviews following survey administration to examine how respondents interpreted questions and why they selected a given response. Also related to content validity, critiques of existing instruments have drawn attention to the necessity of clear conceptualization and a robust, well-articulated, underlying theoretical framework (Messick, 1989).

Thus, the QIAS project set out to develop and validate the 'Arabic-Speaking Students' Attitudes toward Science Survey' (ASSASS, which transliterates into 'foundation' in Arabic). The ASSASS would utilize MSA and be accessible to students in grades 3–12. Item readability was a major consideration, as was the need to avoid coupling items with complex disciplinary scientific contexts that are not familiar to younger students. More importantly, the development of the ASSASS had to be guided by a robust theoretical framework, coupled with the use of robust psychometric analyses to examine the instrument validity and underlying structure.

Development of the ASSASS

The Construct of 'Attitudes toward Science'

'Attitudes toward science' is a broad phrase that has been used to encompass scientific attitudes and interests, as well as attitudes toward scientists, scientific careers, science teaching methods, science curriculum, or the subject(s) of science in the classroom (Blosser, 1984). As a result, researchers (e.g. Aiken & Aiken, 1969; Osborne et al., 2003) have expressed concern over the absence of a clear definition for the construct. A first step toward defining attitudes toward science was to distinguish the construct from 'scientific attitudes' so as to reduce potential confusion resulting from similar wording. Scientific attitudes are taken to refer to particular approaches for solving problems, assessing ideas and information, and/or making decisions (Germann, 1988). Next, researchers thoroughly examined the many conceptualizations of the construct used in the literature.

The notion of measuring attitudes was first opined by the sociologist Thurstone (1928), who pointed out the complexity of the attitude construct. According to Simpson, Koballa, Oliver, and Crawley (1994), attitude entails affective, cognitive, and behavioral components. Many researchers, initially, seemed to have related attitude in this sense to preference. Bem (1970) wrote to the preferential attribute of attitudes, that they represent our 'likes and dislikes' (p. 14). Koballa and Crawley (1985) further explored this quality and connected it to science, by suggesting that attitudes toward science refer to whether a person likes or dislikes science, or has 'a positive or negative feeling about science' (p. 223). Koballa (1988) further articulated this characterization of attitudes dubbed as the evaluative component (Shrigley, Koballa, & Simpson, 1988). Koballa (1988) contended that the most important quality of the attitude concept is our favorable or unfavorable feelings toward objects, persons, groups, or any other identifiable aspects of our environment. As far as attitudes toward science are concerned, such favorable or unfavorable feelings have been explored in relation to science; scientists; and science teachers, teaching, and curriculum; as well as the physical environment of science classrooms (Osborne et al., 2003).

Going beyond the evaluative component, researchers have identified and examined factors that were regularly related to students' attitudes toward science, many of which could be thought of as antecedents or consequences to favorable or unfavorable feelings toward science. Among many other things, the most-often invoked factors include science achievement, science self-concept (including a particular focus on sex and gender), perceptions of the utility of science, perceptions of the expectations of parents/guardians and peers in relation to science, and dispositions toward pursuing additional studies in science or careers in scientific fields (Andre, Whigham, Chambers, & Hendrickson, 1999; Catsambis, 1995; DeBacker & Nelson, 2000; Gardner, 1975; George, 2000, 2006; George & Kaplan, 1998; Hasan, 1985; Keeves, 1975; Kotte, 1992; Shrigley et al., 1988; Simpson & Oliver, 1985; Simpson & Troost, 1982).

Guiding theoretical framework

As could be gleaned from the above discussion, many instruments aimed at measuring attitudes toward science also have addressed students' related behavioral intentions. Researchers have examined the relationship between precollege students' attitudes and their dispositions, interest, and/or intentions to pursue additional studies in science (e.g. Crawley & Coe, 1990; Farenga & Joyce, 1998) and/or scientific or science-related careers (e.g. Mason & Kahle, 1989) both in the near and the distant futures. For example, the Science Opinion Survey (Gibson & Chase, 2002) asks middle school students about their interest in taking another science course in school, as well as about their interest in becoming scientists when they become adults.

Indeed, Koballa (1988) emphasized that a primary goal of measuring students' attitudes toward science is to *predict* student behaviors. Toward making such predictions, researchers and educators have been drawn to social psychological models (Crawley & Koballa, 1994). Many researchers have employed models based on the theory of reasoned action (Ajzen & Fishbein, 1980) to explore students' decision to engage with science (e.g. Crawley & Black, 1992; Crawley & Coe, 1990; Crawley & Koballa, 1992). Ajzen and Fishbein (1980) noted that this theory represents a unifying and systematic conceptual framework, which can be used to explore a range of human behaviors. The theory is based on the assumption that the affective, cognitive, and behavioral aspects of attitude interact in a causal and unidirectional manner (Butler, 1999). The development of the ASSASS was guided by the most recent revision of this theory, namely the theories of reasoned action and planned behavior (TRAPB) (Ajzen & Fishbein, 2005). The TRAPB, it should be noted, account for most of the aforementioned factors that have been consistently investigated, albeit independently in many cases, as pertinent to understanding the relationship between learners' attitudes toward science and their dispositions toward pursuing studies in science or scientific careers (e.g. science achievement, science self-concept, perceptions of the utility of science, and perceptions of the expectations of parents/guardians and peers in relation to science).

The major elements of the TRAPB are defined in Table 1. Figure 1 presents these elements and associated causal model (shaded boxes; adopted from Ajzen & Fishbein, 2005). Ajzen and Fishbein (2005) identified a host of 'background factors' that impact behavioral, normative, and control beliefs. These factors range from the individual (personality, intelligence, experience, etc.) to the social (education, gender, income, culture, etc.), and include available information (knowledge, media, etc.). It should be noted that 'behaviors' and 'actual behavioral controls' (Figure 1, dashed boxes) do not lend themselves to measurement through self-report paper-and-pencil instruments (compared, for instance, to direct observation). These two TRAPB elements, thus, were not addressed in the development of the ASSASS.

The ASSASS items were carefully aligned with the TRAPB elements and model, as well as incorporated known determinants of student attitudes and behavioral intentions. Table 1 outlines the ASSASS constructs and dimensions (Figure 1, unshaded boxes), which were mapped onto major elements of the TRAPB by drawing on Ajzen and Fishbein's (2005) model. These dimensions and constructs were selected and defined based on our and other researchers' systematic reviews of the empirical and conceptual/theoretical research literature on student attitudes toward science (e.g. Osborne et al., 2003, 2009).

In this context, we should note that the authors were aware of concerns related to, and potential shortcomings of the TRAPB, as these might pertain to precollege students' intentional behaviors related to science. Some of these concerns are related to the assumptions underlying the TRAPB about behavior and behavioral intention. Crawley and Coe (1990) defined behavior as 'an overt action under the volitional control and within the individual's capability' (p. 463). It is conceivable that this assumption might not hold in the case of young children because their perceived volitional control over relevant decisions (e.g. to elect to enroll in a science course during their high school freshmen year) might be questionable. Another concern derives from the assumption that actions related to behavioral intentions do not necessarily require special skills or abilities, unique opportunities or the assistance of others, and 'require only that the individual possess the motivation to perform the behaviors' (Crawley & Koballa, 1994, p. 38). An example of the latter behaviors would be fastening the seatbelt when driving a car (Ali, Haidar, Ali, & Maryam, 2011). This assumption, nonetheless, may prove inapplicable in the case of young students thinking about their future academic studies, especially in relation to their real or perceived abilities to succeed in college science. Additionally, like with the ASSASS, a concern underlying the development of many attitude instruments is that anticipated predictive

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Table 1. ASSAS domains and constructs as related to elements of the TRAPB[a]

TRAPB component	Definition (from Ajzen & Fishbein, 2005, p. 193)	Related ASSAS domain or construct	Related ASSAS sub-domain or sub-construct[b]	Items in initial pool	Illustrative ASSASS items
Intention	Antecedent of actual engagement with the target behavior	Intention to pursue, interest in pursuing, science	• Additional or future studies in science • A career in science	6 5	• I will study science if I get into a university • I will become a scientist in the future
Attitude toward the behavior	'A learned disposition to respond in a consistently favorable or unfavorable manner toward an attitude object [in this case, science]'[c]	Attitude toward different facets of science as it relates to student lives	• Attitude toward science • Attitude toward school science • Attitude toward science as leisure	6 11 5	• I really enjoy science lessons • I really like science
Behavioral beliefs	Beliefs about 'the likely consequences of a behavior … outcome expectancies … or costs and benefits … these beliefs and their associated evaluations are assumed to produce an overall positive or negative evaluation or attitude toward performing the behavior in question'	Beliefs about the consequences associated with engagement with science, and beliefs about the benefits associated with science	• Beliefs about consequences associated with becoming a scientist • Beliefs about consequences associated with science learning • Beliefs about the relevance and utility of science: (i) at the societal level; (ii) at the personal level	7 5 16	• Scientists do not have enough time for fun • I look forward to science activities in class • We live in a better world because of science • Learning science is not important for my future success
Control beliefs and perceived behavioral control	'Beliefs concerning the presence or absence of factors that make performance of a behavior easier or more difficult … referred to … as self-efficacy and personal agency … or perceived behavioral control'	Perceived self-efficacy and personal agency toward science learning	• Perceived ability toward learning science • Perceived efficacy of effort toward learning science	5 4	• I am sure I can do well on science tests • I cannot understand science even if I try hard
Normative beliefs and subjective norm[b]	Beliefs 'that deal with the likely approval or disapproval of a behavior by friends, family members … and, in their totality … lead to perceived social pressure or subjective norm to engage or not engage in the behavior'	Perceived approval or disapproval toward engagement with science[b]	• Perceived approval or disapproval by family members and friends	4	• My family encourages me to have a science-related career[b] • My friends do well in science[b]

[a] Note that the two TRAPB components 'actual behavioral controls' and 'behavior' (see Figure 1), which do not lend themselves to measurement through self-report paper-and-pencil instruments, were not addressed in the ASSASS.

[b] This one domain and associated items did not survive into the finalized instrument.

[c] From Fishbein and Ajzen (1975, p. 6).

ability associated with assessing students' attitudes and behavioral intentions is likely to diminish as the perceived or real temporal gap widens between the actual assessment and performance of the target behavior (e.g. asking a seventh grader if she would elect to take a science course in grade eight versus asking her whether she would major in science when admitted to college). The latter concern is more relevant in the case of the QIAS project—with a target population spanning 8–17 year old students—compared to studies which evaluated students' behavioral intentions on short-term bases with data collection spanning approximately 1–4 years before the anticipated performance of the target behavior (e.g. Crawley & Black, 1992). Nonetheless, as noted above, the TRAPB serve to connect a wide range of possible facets and factors that typify and/or impact student attitudes and behavioral intentions in relation to a target domain (Crawley & Koballa, 1994). Thus, the TRAPB serve to link a number of constructs and domains that have been, to various extents and in various combinations, invoked in past instruments and research on student attitudes toward science.

Selection and Development of the Item Pool

The TRAPB allowed identifying a set of domains and constructs that would undergird the development of the ASSASS (see Table 1), and was followed by a thorough and systematic empirical analysis of a dozen widely used science attitude instruments. These instruments included, among others, the Attitude toward Science in School Assessment (Germann, 1988), Attitudes Toward Science Inventory-Modified (Weinburgh & Steele, 2000), Science Attitude Inventory: Modified (Nagy, 1978), Science Attitude Inventory: Revised (Moore & Hill Foy, 1997), Simpson-Troost Attitude Questionnaire: Revised (Owen et al., 2008), and Test of Science Related Attitudes (Fraser, 1978). The analysis aimed to identify the themes, domains, and constructs, as well as corresponding items, which cut across existing instruments. The analysis reinforced the selection of the domains and constructs underlying the ASSASS, as well as enabled the adoption—in several cases with revision—of a number of existing items that were aligned with the ASSASS. A total of 62 items were adopted, 16 of which were modified. A full account of those adopted or revised items, which persisted into the final version of the ASSASS, appears in Table 3. We also developed a dozen more items to ensure that all of the ASSASS domains and constructs are addressed. This effort resulted in a pool of 74, 5-point (strongly disagree, disagree, not sure, agree, and strongly agree) Likert scale items (see Table 1). This initial item pool, it should be noted, was intentionally much larger than the anticipated number of items for the final version of the ASSASS. The pool comprised some similar items, or large sets of items for some constructs or domains (see Table 1), and next stages of instrument development were meant to select the most appropriate among these items.

Face and Content Validity

An international panel of experts established the face and content validity of the instrument. Panel members were carefully selected to cover expertise with research on

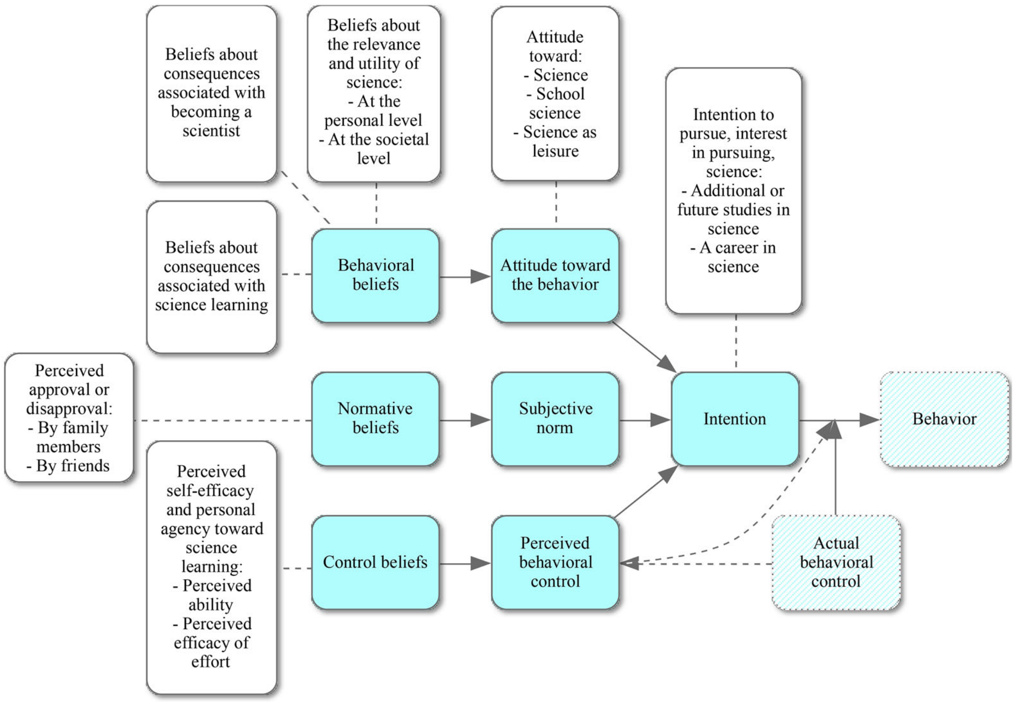

Figure 1. The ASSASS conceptual framework showing initial domains and constructs (clear boxes) that map onto major TRAPB elements (shaded boxes; adopted from Ajzen & Fishbein, 2005) that are amenable to measurement by self-report paper-and-pencil instruments

precollege students' attitudes toward science, science education research, science teaching and learning, and the Arab and Qatari educational contexts, as well as to include science educators who were fluent in English and MSA. The panel comprised 10 experts with the following combined qualifications: Eight science education or science college faculty members (three from national Qatari universities; five from international universities), two experts in science education research, a researcher who is considered an authority in the domain of attitudes research in science education, and two pre-college science education personnel from Qatari schools. Five of the panel members are fluent in both spoken and written English and MSA.

The panel examined the aforementioned pool of 74 ASSASS items. Panel members were asked to provide feedback on the constructs and domains underlying the instrument, the fit of each item in the pool with its respective construct or domain, the wording of each item, and the appropriateness of the language for use with students keeping in mind the youngest of the target population (i.e. grade 3 students). Panel members also were asked to suggest revisions for an item in case they identified issues with its wording, provide justification for recommending that an item be deleted, as well as suggest additional items in case they thought this was necessary. The panel's feedback, which mostly pertained to individual items, was systematically analyzed. As a result, 37 (50%) of the 74 original items submitted for review remained unchanged, 21 (28%) were modified, 16 (22%) were deleted, and 10 new items were added. Completion of the recommended revisions, along with further consolidation of items addressing similar constructs or domains, resulted in a 60-item version of the ASSASS. An overall concern of the panel was related to item readability by the youngest students despite an ongoing awareness of this issue through the item selection, revision, and development process. To alleviate this concern, the panel suggested that the survey items be read aloud to third- and fourth-grade students.

We headed Munby's (1982) caution regarding the overreliance on advisory panels for establishing the face validity of an instrument, especially that the meanings attributed to the items by an expert panel will not be the same as those attributed by respondents. As will be detailed below, we followed Osborne et al.'s (2009) methodological suggestion to address this concern. Following the pilot administration of the instrument, we used individual interviews to examine how respondents interpreted the items and why they selected a given response.

Instrument Validation

Validation of the ASSASS proceeded in two phases. A small-scale pilot study first was used to examine the instrument's underlying structure, assess the quality of its items, and reduce the instrument's length. The pilot was followed by a large-scale validation of the resulting version of the instrument with a national probability sample.

Administration Procedures

In the case of both pilot and large-scale administrations, participant students completed the instrument in their classrooms under the supervision of their regular classroom teacher and a QIAS research assistant. QIAS personnel strictly followed a scripted, standard protocol for introducing the study, securing informed consent and explaining associated assurances, giving instructions to complete the instrument, and monitoring students as they answered survey items. In the case of third and fourth graders, QIAS personnel slowly read the ASSASS items aloud in a neutral tone, pausing after each item to give students ample time to respond. Students were allotted one, 50-minute class period to complete the survey. The actual completion time ranged from 35 to 45 minutes. Also, given that the majority of the Qatari population is composed of (Arab and non-Arab) expatriates who live and work in this nation, the ASSASS was made available to students in both English and MSA. Backward translation was used to ensure the equivalency of the two versions.

The Qatari Educational Context

The State of Qatar is a small, affluent, and gas- and oil-rich nation of about two million people located on the Persian Gulf. Qatari and other Arab nationals constitute about 40% of the population with non-Arab expatriates accounting for the remainder of the

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nation's residents (Central Intelligence Agency, 2013). The 'Education for a New Era' reform initiative of 2002 outlined a sweeping, multi-step plan to rejuvenate the Qatari educational system (Zellman et al., 2007). The existing educational system was deemed excessively rigid and outmoded with an emphasis on traditional instructional practices. As part of the reforms, the year 2004 witnessed the introduction of new pre-college school curriculum standards.

Prior to 2002, schools in Qatar could be categorized as: Ministry of Education schools, independent schools, international and community schools, and private Arabic schools that catered to the large Arab expatriate communities residing in Qatar. Along with curricular changes, the 2002 reform initiative was accompanied by a reorganization of schools. The reform mandated that, starting in 2004, new government-funded schools would be established but not operated by the Ministry of Education (Zellman et al., 2007). The latter schools were first labeled as semi-independent to indicate that, while funded by the state, independent operators ran these schools. Eventually, with the conclusion of the reform process in the 2010–2011 academic year, both semi-independent and independent schools were now labeled as independent. However, given that data collection for validating the ASSASS was completed during the transitional period, the distinction between independent and semi-independent schools was maintained for purposes of data analysis. At the time of data collection, about 300 schools operated in Qatar serving about 150,000 students. Roughly, 40% of these schools were semi-independent, 23% independent, 11% private Arabic, and 26% international and community schools.

Results

Pilot Study

Sample. A sample of 12 schools was purposively selected to represent the various types and levels of Qatari schools. Using the intact grade as the unit of selection, a stratified random sample was drawn from the pool of all grades and grade sections in the range of grades 3–12 in the selected schools. The resulting sample comprised 395 students. Of those, 390 students completed the 60-item pilot version of the ASSASS, including 21 students (5.4%) who completed the English version. A total of 369 students (55.6% male, 44.4% female) responded to the Arabic version. Their mean ages ranged from 8.7 to 17.3 years. Of the students, 146 (39.6%) were in primary school (grades 3–6), 111 (30.1%) in preparatory school (grades 7–9), and 112 (30.4%) in secondary school (grades 10–12). An average of 37 students per grade level responded to the instrument, with a range of 25–53 students per grade level. Data analyses focused on the 369 surveys that were completed in Arabic.

Post-Administration Interviews. Following the administration of the pilot ASSASS version, a random sample of roughly four students per grade level (40 students total, representing approximately 11% of the total number of pilot students) was selected for individual exit interviews. The interviews, which were conducted by

QIAS research assistants, aimed to elucidate student interpretations of the instrument's items. Students were asked to comment on the survey as a whole, as well as on a systematically selected subset of individual items. Given the participants' age range, it would have been burdensome to ask each student—especially the younger ones, to comment on all 60 items. Thus, students were asked to explain how they interpreted a subset of 15 items, identify terms or items that were hard to understand in this subset, and suggest ways to revise the latter terms or items. As a result, 10 students (about 3 per school level—that is, elementary, preparatory, and high school) described their interpretations of, and provided feedback on, each of the 60 items in the pilot version of the ASSASS. Analyses of the interview data indicated that, overall, the ASSASS items were accessible and understandable to participant students. These data were used to make minor edits and revisions to a number of items, especially substituting terms that were less familiar to participants with more familiar ones, with a particular focus of feedback provided by younger participants. Interview data also flagged a number of pilot items as problematic. As explained below, these items were eventually deleted from the large-scale administration of the instrument.

Data Analysis. First, the scores for negatively worded items were reversed. Exploratory Factor Analysis (EFA) was used to avoid imposing the theoretically motivated TRAPB model (Figure 1, Table 1) on the pilot data. EFA was conducted with MPlus, allowing cases with missing values on some of the variables to be included in the model. EFA identified a strong core of items, with several related item clusters. Obtained Eigenvalues, nonetheless, did not suggest a clear number of factors to extract. Although the first Eigenvalue (14.76) was quite strong, subsequent analyses indicated that a single global factor did not have the best fit among, or outperform, alternative models. Models with between four and seven factor solutions were analyzed using Promax rotation. A five-factor model was nominated from the various factor solutions, demonstrating conceptually sound item groupings, with a cutoff value for factor loadings set at 0.32 (Tabachnick & Fidell, 2001). Based on item content, the five factors were labeled: Attitudes toward science and school learning (attitude), unfavorable outlook on science (unfavorable outlook), control beliefs about ability in science (control beliefs), behavioral beliefs about the consequences of engaging with science (behavioral beliefs), and intention to pursue science (intention). The five factors were low to moderately correlated: Seven correlations ranged from .05 to .29, while the remaining three correlations ranged from .46 to .50.

Next, to empirically address the aforementioned concerns raised by the expert review panel with regard to item readability for the youngest students in the population, we investigated item difficulty by comparing responses from 3rd and 4th graders with those from 11th and 12th graders. This analysis helped identify a pool of items that were arguably problematic for the younger students—and, thus, candidate for deletion—as evident in relatively poor item loadings with the five-factor model when compared to the loadings of these item responses from the older students. Confidence in deleting many of these items was bolstered by analyses of the aforementioned post-administration interview data, which have flagged some items as presenting, from the students' perspective, some difficulty, and/or ambiguity. A number of additional items failed to load or had poor loadings (< 0.32) on the five-factor model and, thus, were also excluded.

At the conclusion of the pilot study, 35 of the 60 pilot items were retained in the ASSASS instrument. The associated factor loadings were quite robust. Even though the cutoff value for factor loadings was set at 0.32 (Tabachnick & Fidell, 2001), almost all of the EFA factor loadings for the 35 retained items were above 0.40 and no item had a factor loading below 0.35. In general, three or more items per factor enable the generation of an identifiable model (Anderson & Gerbing, 1984). Four of the five factors in the generated model comprised five or more items. However, only 2 items (with factor loadings at .41 and .44) were retained under the control beliefs factor (see Table 3), which is less than the generally accepted minimum. However, research has indicated that when multiple other factors are present with more than three items, a model is still identifiable when a single factor includes only two items (Anderson & Gerbing, 1984; Ding, Velicer, & Harlow, 1995).

Large-Scale Validation

Sample. All schools registered with the Qatari Ministry of Education were contacted to solicit information about their 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 3–12 across all respondent schools and school types. Next, four sections per grade level (in grades 3–12) and school type (independent, semi-independent, international, community, and private Arabic) were randomly selected from this database resulting in a sample of 200 class sections. Complete responses to the ASSASS were collected from 3027 students (51.2% female, 45.3% male, 3.4% unreported) in 144 sections (72% sectional response rate) from 79 different schools. Respondents were 31.4% Qatari, 33.2% non-Qatari Arabs, and 29.9% with 'other' nationalities, while 5.5% of the respondents did not report their nationality.

The reader is reminded that the ASSASS was made available to respondents in both Arabic and English. A total of 1978 respondents (65.3%) completed the survey in Arabic. Of those, 88.2% were Qatari and non-Qatari Arabs, and 7.4% were from other nationalities (6.5% unreported). Of the 1049 students who completed the survey in English, only 9.5% were Qatari and 14.4% non-Qatari Arabs. Given that the primary goal was to validate an instrument to assess Arabic-speaking students' attitudes toward science, ensuing data analyses focused on data generated from the Arabic version of ASSASS. The analysis did not include the 251 Qatari and non-Qatari Arab respondents who completed the survey in English to avoid any conflation resulting from these students not completing the ASSASS in their native language. Comparative analyses of the results by language (i.e. Arabic versus English) will be reported elsewhere.

Table 2 presents an overview of the final sample for the large-scale validation of the Arabic version of the ASSASS, which comprised a total of 1978 students (55.2%

female, 41.8% male, 3.1% unreported). An average of about 10 sections (with a range of 7–12 sections) and about 200 students (with a range of 134–261 students) per grade level completed the survey. As could be expected by limiting data analyses to surveys completed in Arabic, all types of schools in Qatar were well represented in their proportion to the total population of schools with the exception of international schools, where roughly 68.3% of Qatari and 54.9% of non-Qatari Arab students completed the ASSASS in English. The number of respondent sections for independent, semi-independent, community, and private Arabic schools were 34 (35.4%), 33 (34.4%), 11 (11.5%), and 17 (17.7%), respectively (see Table 2).

Data Analysis. Confirmatory Factor Analysis (CFA) was applied to the large-scale data using the five-factor model generated from the EFA. Analyses indicated robust item loadings on this model for the validation data (see Table 3). Three of the 35 items used in the analysis loaded on multiple factors and were removed. With a Root Mean Square Error of Approximation (RMSEA) of 0.032, the finalized 32-item, five-factor model demonstrated close fit with the data (Browne & Cudeck, 1993; Byrne, 1998). All factor loadings were significant ($p < .001$) and indices of model fit were very robust. The final model showed a Standardized Root Mean Square Residual of 0.037 (values < 0.05 indicate close approximate fit), a Comparative Fit Index of 0.937 (values > 0.9 represent reasonably good fit), and a Tucker Lewis index of 0.931 (values > 0.9 indicate reasonably good fit) (see Hu & Bentler, 1999).

The final version of the ASSASS, which appears in Appendix 1, comprised a total of 32 items under five factors or sub-scales (see Table 3 and Figure 2). Scale reliability, also referred to as construct reliability, was estimated based on the CFA results (Dillon & Goldstein, 1984; Jöreskog, 1971) and reported instead of Cronbach's alpha due to its increased dependability (Raykov, 2001). Note that scale reliability is evaluated in a manner similar to Cronbach's alpha, with values greater than 0.6 considered acceptable, and values between 0.7 and 0.9 considered good. The five ASSASS sub-scales showed robust reliabilities, ranging 0.61–0.87 (see Table 4). As noted earlier, the control beliefs' sub-scale contains only two items. Sub-scales with fewer than three items often achieve poor reliabilities. Nonetheless, with a reliability of 0.61, this sub-scale demonstrated acceptable reliability. Finally, as will be articulated below, the final five-factor ASSASS model made for a conceptually robust and interpretable model.

Discussion

The five-factor model for the ASSASS showed very robust indices of fit and sub-scale reliabilities. More importantly, the model was conceptually interpretable and reasonably well aligned with the TRAPB. In other words, as explicated below, the model has something important to say about the relationship between precollege students' attitudes and intentions in relation to science in Qatar. Four ASSASS sub-scales

Table 2. National representative student sample for the ASSASS large-scale validation ($N = 1978$)

School	Level(s)	Grade: Sections *n*	Grade: Sections %[a]	Grade: Number *n*	Grade: Number %[a]	Students (Sex): Male *n*	Male %[b]	Female *n*	Female %[b]	Not reported *n*	Not reported %[b]
School level											
Primary	3	12	12.5	224	11.3	104	46.4	109	48.7	11	4.9
	4	9	9.4	208	10.5	84	40.4	120	57.7	4	1.9
	5	9	9.4	180	9.1	54	30.0	119	66.1	7	3.9
	6	9	9.4	207	10.5	68	32.9	130	62.8	9	4.3
Total	–	39	40.6	819	41.4	310	37.9	478	58.4	31	3.8
Preparatory	7	13	13.5	261	13.2	92	35.2	165	63.2	4	1.5
	8	9	9.4	218	11.0	142	65.1	71	32.6	5	2.3
	9	9	9.4	177	8.9	100	56.5	76	42.9	1	0.6
Total	–	31	32.3	656	33.2	334	50.9	312	47.6	10	1.5
Secondary	10	9	9.4	171	8.6	77	45.0	83	48.5	11	6.4
	11	7	7.3	134	6.8	47	35.1	80	59.7	7	5.2
	12	10	10.4	198	10.0	58	29.3	138	69.7	2	1.0
Total	–	26	27.1	503	25.4	182	36.2	301	59.8	20	4.0
Grand total	–	96	100.0	1978	100.0	826	41.8	1091	55.2	61	3.1
School type											
Independent		34	35.4	678	34.3	277	40.9	389	57.4	12	1.8
Semi-independent		33	34.4	667	33.7	172	25.8	472	70.8	23	3.4
International		1	1.0	21	1.1	17	81.0	0	0.0	4	19.0
Community		11	11.5	259	13.1	102	39.4	152	58.7	5	1.9
Private Arabic		17	17.7	353	17.8	258	73.1	78	22.1	17	4.8
Grand total	–	96	100.0	1978	100.0	826	41.8	1091	55.2	61	3.1

[a] Percent of grand total.

[b] Percent of corresponding grade or school level.

mapped onto four of the five TRAPB components. An examination of Table 1 and Table 3 shows that the 'attitude toward science and school science' (attitude) and 'behavioral beliefs' sub-scales mapped perfectly onto the 'attitude toward the behavior' and 'behavioral beliefs' components of the TRAPB. The fit between the intention ASSASS sub-scale and corresponding TRAPB component was very high with a single exception—namely the item, 'My family encourages me to have a science related career', which, prima facie, seems to be gravely misplaced. The 'control beliefs' sub-scale maps partially onto the 'control beliefs and perceived behavioral control' component of the TRAPB. Namely, only items that pertain to perceived ability toward learning science (e.g. 'I am sure I can do well on science tests') load onto this sub-scale, which was not the case for items that were intended to access perceived efficacy of effort toward science learning (e.g. 'I cannot understand science even

Table 3. Standardized factor loadings based on CFA for the large-scale administration data ($N = 1978$)

Item	Attitude	Unfavorable outlook	Control beliefs	Behavioral beliefs	Intention
16. I really enjoy science lessons[a]	0.81				
24. I really like science[b]	0.80				
1. I enjoy science	0.76				
8. Science is one of the most interesting school subjects[c]	0.75				
15. I look forward to science activities in class	0.63				
9. My science teachers are very good[d]	0.58				
11. I like to watch TV programs about science[e]	0.55				
3. We do a lot of interesting activities in science class[f]	0.52				
21. I will miss studying science when I leave school	0.41				
30. Science lessons are a waste of time[c]		0.66			
25. If I could choose, I would not take any more science in school		0.59			
12. I cannot understand science even if I try hard[g]		0.57			
7. I usually give up when I do not understand a science concept		0.49			
27. Scientific work is only useful to scientists[h]		0.49			
31 Scientists do not have enough time for fun[i]		0.46			
2. Learning science is not important for my future success[j]		0.45			
10. I will not pursue a science-related career in the future		0.43			
6. Scientific discoveries do more harm than good		0.39			
18. I am confident that I can understand science			0.75		
5. I am sure I can do well on science tests[k]			0.56		
28. Science will help me understand the world around me[l]				0.70	
22. Knowing science can help me make better choices about my health[l]				0.69	
26. Knowledge of science helps me protect the environment				0.63	
19. We live in a better world because of science[d]				0.63	
13. Science is useful in solving everyday life problems[g]				0.53	
32. People with science-related careers have a normal family life				0.38	

(*Continued*)

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Table 3. Continued

Item	Attitude	Unfavorable outlook	Control beliefs	Behavioral beliefs	Intention
20. I would enjoy working in a science-related career					0.81
17. I will continue studying science after I leave school					0.77
29. I will take additional science courses in the future[m]					0.68
4. I will study science if I get into a university					0.62
23. My family encourages me to have a science-related career					0.58
14. I will become a scientist in the future					0.53

Item(s) source:

[a] Modified from Fraser (1978).

[b] From Owen et al. (2008).

[c] From Fraser (1978).

[d] Modified from Wareing (1982, 1990).

[e] Modified from Harty and Beall (1984).

[f] Modified from Owen et al. (2008).

[g] Modified from Weinburgh and Steele (2000).

[h] From Moore and Hill Foy (1997).

[i] From Nagy (1978).

[j] From Siegel and Ranney (2003).

[k] From (Tuan, Chin, and Shieh, 2005).

[l] From Siegel and Ranney (2003).

[m] Modified from Gibson and Chase (2002).

The authors developed the remaining items.

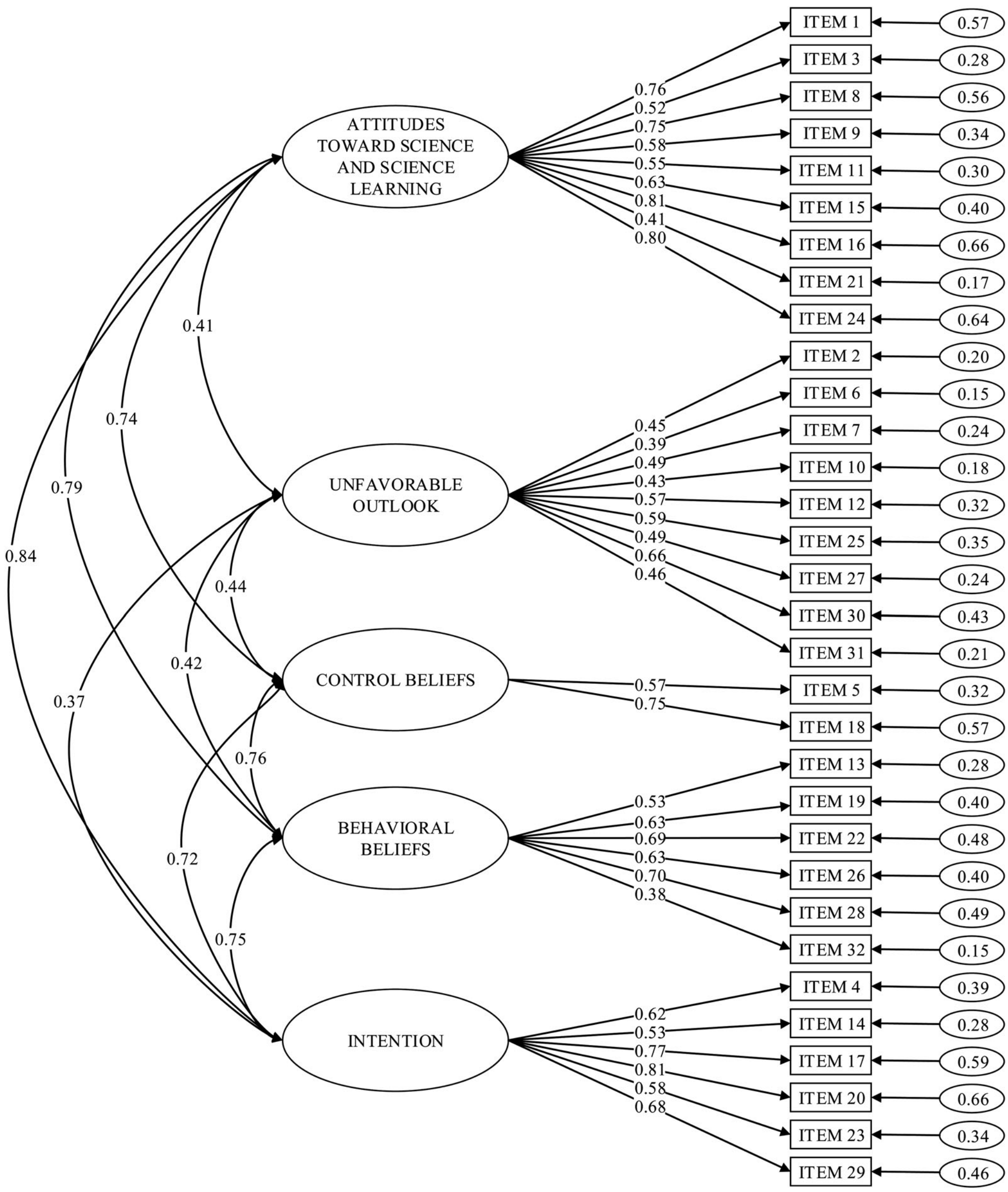

Figure 2. Finalized model and standardized item factor loadings from CFA with the large-scale, validation data. Item numbers correspond to those listed in the finalized instrument shown in Appendix 1

if I try hard'). The latter items loaded onto the unfavorable outlook sub-scale. No ASSASS sub-scale, however, mapped onto the 'normative beliefs and subjective norm' dimension of the TRAPB. Finally, as explained below, the 'unfavorable outlook' sub-scale had more of a composite structure having mapped onto elements

Table 4. CFA-based scale reliabilities for the final ASSASS model

Sub-scale	Reliability
Attitude	0.87
Negative outlook	0.75
Control beliefs	0.61
Behavioral beliefs	0.77
Intention	0.83

from the attitude toward the behavior, and behavioral and control beliefs, as well as intention dimensions of the TRAPB.

The ASSASS model suggests that respondents do indeed have distinct attitudinal reactions to science and school science that were favorable (attitude) or unfavorable (unfavorable outlook). A close examination of these two sub-scales and associated items reveals two interesting features (see Table 3). First, it could be seen that respondents did not seem to conceive of science and school science as two distinct entities; rather, the two were parceled together in the attitude sub-scale. Items that talked to attitudes toward science (e.g. 'I really like science') and those that addressed attitudes toward school science (e.g. 'I look forward to science activities in class'), as well as the item related to attitudes toward science as leisure ('I like to watch TV programs about science') all had strong loadings (0.41–0.81) on the same sub-scale. In other words, to impact student attitudes toward school science, a proximal experience for them is to impact their attitudes toward science—a distal prospect experienced only by proxy. It is unlikely that precollege students could develop or sustain a disposition toward science of the sort, 'I do not like school science now, but it is likely that I will enjoy science in the future because science is very different from the science I experience in school'.

Second, equally important, the attitude and unfavorable outlook sub-scales were substantively non-symmetrical: The latter did not merely comprise negatively worded items about attitudes toward science and school science that loaded on the former sub-scale. The unfavorable outlook sub-scale included negatively worded items related to school science (e.g. 'Science lessons are a waste of time'). However, negatively worded items in the pilot ASSASS version that related to student attitudes toward science, such as 'I do not like science' did not survive into the finalized model. The unfavorable outlook factor, as noted above, is a composite sub-scale comprising a number of elements, including negative dispositions toward: school science, beliefs about the personal utility (e.g. 'Learning science is not important for my future success') and social utility (e.g. 'Scientific discoveries do more harm than good') of science, beliefs about the consequences of becoming a scientist (e.g. 'Scientists do not have enough time for fun'), perceived efficacy of effort toward learning science (e.g. 'I cannot understand science even if I try hard'), and intention to pursue science studies (e.g. 'If I could choose, I would not take any more science in school').

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The unfavorable outlook sub-scale represented a watershed for various attributes that seemed to generate negative dispositions toward science. In effect, these results indicate that students' unfavorable attitudes toward science intertwine with a number of dimensions related to science that, nonetheless, do not articulate into distinguishable sub-domains from students' perspectives, as would be expected if young students were asked to verbally explicate or clearly identify factors that underlie their feelings toward science in the context of an individual interview. Here, it should be noted that, unlike the case of the other ASSASS factors, the covariance of the unfavorable outlook and other sub-scales were only moderate in magnitude (0.37–0.44), as compared to the mostly high covariance values among the remaining four factors (see Figure 2). The characteristics of the 'unfavorable outlook' factor and its lack of alignment with the TRAPB, which guided the development of the ASSASS, indicate a need for further empirical investigations to determine whether this dimension is an artifact of the ASSASS instrument (or a subset of its items) and/or particular population for the present study, or is reflective of some actual, deeper social and/or cultural attributes of students and/or schooling in Arab nations.

As noted above, no ASSASS sub-scale addressed the normative beliefs and subjective norm dimension of the TRAPB, which speaks to perceived approval or disapproval of significant others (in the present case, family and peers) toward engagement with the target behavior or object (in the present case, science). Items related to this dimension either did not make it to the final ASSASS model (e.g. 'My friends like science') or eventually loaded on other sub-scales (e.g. 'My family encourages me to have a science-related career'). The latter item, as noted earlier, loaded on the intention sub-scale. These results might be explicable on cultural differences, namely between Western cultures where the TRAPB was developed, and Middle Eastern or Arab culture, where data for the present study were collected. In particular, in the context of Arab culture, parents/guardians might have substantially more say in their children's academic choices than is the case in Western cultural contexts. In other words, respondents might have not perceived that their preferences had substantial weight—at least, not to the extent they do in Western cultures—when it comes to making decisions about their short or long-term academic trajectories. Thus, items that addressed perceived parental or peer approval for engagement with science did not cluster into an identifiable factor. Confidence in this inferred explanation is further bolstered by the fact that it also serves to explain the aforementioned 'misplaced' loading of the item, 'My family encourages me to have a science-related career' on the ASSASS intention sub-scale. In a sense, respondents seem to value and accord high priority for the input of their parents/guardians into their academic trajectories so as to consider such input as part and parcel of formulating their very intentions to pursue additional science studies or scientific careers in the future.

Conclusions

To the best of our knowledge, the ASSASS was the first such large-scale effort to develop and validate an instrument specifically geared to assessing pre-college Arab students' attitudes toward science and their behavioral intentions to pursue science studies and related careers. The development of the ASSASS heeded and systematically addressed concerns that have been highlighted as having compromised the validity and/or reliability of many of the existing paper-and-pencil attitudes toward science instruments (Blalock et al., 2008; Osborne et al., 2003, 2009). Methodological safeguards undertaken during the development and validation of the ASSASS ranged from anchoring the development of the instrument in a robust theoretical model, to coupling the use of an expert panel's feedback to establish the instrument's face and content validity with feedback from intended respondents, to a multi-phase development and validation process including a sizable pilot study, to using robust statistical measures to explore the instrument's underling psychometric properties and structure. The results indicate that the five sub-scales underlying the ASSASS produce a robust model with a good fit, and good reliability and validity measures, as well as a model that highly likely will generate data that are meaningful and interpretable given its alignment with the TRAPB. By utilizing MSA to develop the ASSASS, the instrument will have wide applicability throughout the Arab world, where interest in the development of better attitudes toward, and increased interest in, science among precollege students are highly valued outcomes. The development of the ASSASS also indicated that the relationship between the construct of attitudes toward science, and its associated determinants, as well as consequences is very complex and worthy of further rigorous investigation.

Finally, the ASSASS instrument would benefit greatly from further empirical examinations of its utility, as well as the validity and applicability of its underlying five-factor model, in other nations and educational contexts. Surely, much additional research, including longitudinal studies, is needed to establish the criterion-related or predictive validity of the ASSASS, that is, whether the instrument could potentially predict the desired student behaviors. These behaviors include whether learners in the near, medium, or distant future would actually elect to enroll in more science courses in the next academic year or grade band, actually elect to major in a science-related discipline in college, or actually pursue a science-related career later in life, respectively.

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Appendix 1

Item	SD[b]	D[b]	NS[b]	A[b]	SA[b]
ASSASS[a]					
I enjoy science	○	○	○	○	○
Learning science is not important for my future success	○	○	○	○	○
We do a lot of interesting activities in science class	○	○	○	○	○
I will study science if I get into a university	○	○	○	○	○
I am sure I can do well on science tests	○	○	○	○	○
Scientific discoveries do more harm than good	○	○	○	○	○
I usually give up when I do not understand a science concept	○	○	○	○	○
Science is one of the most interesting school subjects	○	○	○	○	○
My science teachers are very good	○	○	○	○	○
I will not pursue a science-related career in the future	○	○	○	○	○
I like to watch TV programs about science	○	○	○	○	○
I cannot understand science even if I try hard	○	○	○	○	○
Science is useful in helping solve everyday life problems	○	○	○	○	○
I will become a scientist in the future	○	○	○	○	○
I look forward to science activities in class	○	○	○	○	○
I really enjoy science lessons	○	○	○	○	○
I will continue studying science after I leave school	○	○	○	○	○
I am confident that I can understand science	○	○	○	○	○
We live in a better world because of science	○	○	○	○	○
I would enjoy working in a science-related career	○	○	○	○	○
I will miss studying science when I leave school	○	○	○	○	○
Knowing science can help me make better choices about my health	○	○	○	○	○
My family encourages me to have a science-related career	○	○	○	○	○
I really like science	○	○	○	○	○
If I could choose, I would not take any more science in school	○	○	○	○	○
Knowledge of science helps me protect the environment	○	○	○	○	○
Scientific work is only useful to scientists	○	○	○	○	○
Science will help me understand the world around me	○	○	○	○	○
I will take additional science courses in the future	○	○	○	○	○
Science lessons are a waste of time	○	○	○	○	○
Scientists do not have enough time for fun	○	○	○	○	○
People with science-related careers have a normal family life	○	○	○	○	○

[a] Contact the authors for a copy of the full Arabic version of the instrument including questions about respondents' biographical and background information, as well as detailed instructions for completing the survey.

[b] SD = strongly disagree; D = disagree; NS = not sure; A = agree; and SA = strongly agree. The positions are spelled out on the full instrument because abbreviations might distract younger students.