# COMPARING MEDIATED EFFECTS OF MOTIVATIONAL BELIEFS IN LEARNING SCIENCE OF ADOLESCENTS IN AMERICA AND SINGAPORE: A STRUCTURAL EQUATION MODELING APPROACH

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**Abstract**

American adolescents have been criticized to lack competency in science, technology, engineering, and mathematics compared to Asian countries, causing grave concerns in the country. To gain insights from psychological perspective in education, the present study examined the mediated effects of American adolescents' motivational beliefs on science career aspiration as compared to their peers in Singapore. A structural equation modeling analysis was conducted for both countries using TIMSS data in 2011 to investigate the relationships among several key psychological constructs in learning science such as science self-efficacy, science self-concept, instrumental motivation and career aspirations. Findings revealed that (1) American adolescents' science self-efficacy significantly predicted their career aspirations in science while Singaporean eighth graders' science self-concept was a significant predictor for career aspirations; (2) adolescents' instrumental motivation was more influenced by science self-efficacy rather than by science self-concept in two nations; (3) instrumental motivation positively mediated the relationships between science self-efficacy and career aspirations. Specifically, with introduction of instrumental motivation, American students' science self-efficacy had both direct and indirect effects on career aspirations whereas Singaporean students' science self-efficacy had only indirect effects on the outcome. Implications based on findings were discussed.

*Keywords*: mediation, motivational beliefs, career aspirations, structural equation modeling

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## Introduction

Science penetrates every aspect of our daily life. Full acculturation into advanced scientific and technological societies demands the understanding of science principles and techniques (Rowlands, 2008). Guidance on how the future workforce demand might be accommodated in science, technology, engineering, and mathematics (STEM) was released by the President's Committee of Advisors on Science and Technology (National Research Council, 2010). Given the importance of all students becoming scientifically literate, enhancing science literacy of adolescents has been at the forefront of K-12 educational concerns in the United States (Feinstein, 2011; Kelly, 2011). An alarming decline of college enrollments in STEM and a fluctuation of science interest among high school students add urgency to the concerns (Lips & McNeill, 2009). The evidence of a performance gap in science and mathematics found in the report of Trends in International Mathematics and Science Study (TIMSS) 2007 (Gonzales, Williams, Jocelyn, Roey, Kastberg, & Brenwald, 2008), warned that American adolescents' competencies in science fell behind their peers in other nations (e.g., Singapore) and, to make things worse, it dropped progressively lower when their grade level moved forward to eighth grades.

Science subjects in middle schools are considered an important gateway for almost all science courses in high schools and future careers in STEM (Snead & Snead, 2004; Cleaves, 2005). Steen (1987) held that adolescents who had a lack of success in middle school science often withdrew from the pursuit of subsequent science-related courses and STEM careers. An investigation by the National Science Teacher Association (2003) also asserted that if students could not capture their interest and enthusiasm in science by grade 7, they might never find their way back to science. Hence, science educators seek to foster adolescents' beliefs in their abilities to take responsibility for learning science, and to enjoy and pursue scientific careers (Sanfeliz & Stalzer, 2003; Wigfield, Byrnes, & Eccles, 2006).

Since 1990's, internationally, adolescents' motivational beliefs in science such as intrinsic value of science (i.e., like learning science), instrumental motivation in science (i.e., utility value), science self-concept, and science self-efficacy (i.e., self-confidence in learning science) have been assessed by TIMSS. In the last three decades, Singapore has ranked among the top four countries in the world on TIMSS science tests (Martin, Mullis, & Foy, 2008; Martin, Mullis, Gonzalez, & Chrostowski, 2004; Martin, Mullis, Gonzalez, Gregory, Smith, et al., 2000). Many researchers and educators were curious about why Singaporean students consistently excel in international science exams. Some studies explored the unique characteristics of the educational system and teacher's performance management between America and Singapore (Steiner, 2010). Others investigated students' background characteristics and school factors associated with academic achievements (Areepattamannil, Chiam, Lee, & Hong, 2015). Based on studying the TIMSS data in 2007, Yu (2012) claimed that the science competency of American and Singaporean adolescents was not tied to enjoying science. Of interest from psychological perspective, the role of instrumental motivation in science (i.e., ''I need to do well in science to get the job I want'') was a negative predictor of science achievement for Singaporean students, whereas it was significantly and positively correlated to eighth-grade students' performance in science in the United States.

Previous studies of motivation underlined the important influences of students' self-beliefs such as academic self-concept, and learning environments (like schools and classrooms) on science achievements (Zimmerman & Schunk, 2011; Palmer, 2005; Ames, 1992), but few studies have assessed the influence of students' instrumental motivation on the associations between students' self-beliefs and science career aspirations, which is the most important career-oriented indicators in STEM field.

The present study aimed to better understand the associations among motivational beliefs in learning science and career aspirations of eighth-grade students in America and Singapore, using large-scale data from TIMSS 2011. The findings of the present research expanded the existing literature in three important ways:

1. This study investigated the associations among motivational beliefs (i.e., science self-efficacy, science self-concept, intrinsic value of science, and instrumental motivation) in learning science, which deepened our understanding to the correlate relationships among motivational beliefs in science domains.
2. The present study compared the relations between science career aspirations and motivational beliefs in learning science of adolescents in America and Singapore. The findings aided to clarify the influence of motivational beliefs of adolescents in learning science in two nations and gained insights through the comparison.
3. A mediation analysis was conducted to explore the direct and indirect effects of these learning constructs with the introduction of instrumental motivation as a mediator on students' career aspirations in America and Singapore.

## Literature Review

### Theoretical Perspective

The expectancy-value theory is dominant in the achievement motivation of education (Eccles, 1983; Eccles & Wigfield, 1995; Wigfield & Eccles, 2000). The crucial constructs of the expectancy-value model developed by Wigfield and colleagues include expectancies for success, ability beliefs, and the components of subjective task values (Wigfield & Eccles, 2002). The construct of individual own expectancies for success is similar to Bandura's efficacy expectation construct (Bandura, 1997; Wigfield & Eccles, 2002). Eccles and her colleagues (2005) proposed that student motivation was influenced by his or her subjective task values and task-specific beliefs such as perceptions of competence (i.e., self-concept). Subjective task values are multidimensional constructs comprised of attainment value, intrinsic value, utility value, and cost (Eccles, O'Neil, & Wigfield, 2005). Though a variety of constructs of motivation have potentials to inform student motivation of learning science in school settings (Schunk, Meece, & Pintrich, 2012), academic self-efficacy, self-concept, intrinsic value, and instrumental motivation are main components of motivational constructs of learning (Simpkins, Davis-Kean, & Eccles, 2006). Therefore, the present study focused on science self-efficacy, science self-concept, intrinsic value of science, and instrumental motivation in learning science (i.e., utility value).

**Conceptual Framework**

**Academic self-efficacy.** Self-efficacy is defined as a judgment of the confidence that one has in one's abilities, that is associated with the amount of individual stress and anxiety experienced when engaging in an activity (Pajares, 1996). Academic self-efficacy represents the learners' subjective beliefs in their own confidence for highly specific academic achievements (Tang & Neber, 2008).

**Academic self-concept.** Self-concept is denoted as one's own perceived self, accompanied by an evaluative judgment of self-worth. Academic self-concept refers to a person's "perception of self with respect to achievement in school" (Reyes, 1984, p. 559; Green, Liem, Martin, Colmar, Marsh, & McInerney, 2012).

**Intrinsic value**. Intrinsic value, an important component of motivational belief, is defined as an individual's subjective interest in the subject or the enjoyment or satisfaction that a person gets from performing the activity (Eccles & Wigfield, 2002; Hofer, 2010).

**Instrumental motivation.** Instrumental motivation, indeed, is an extrinsic motivation, indicating that the present actions are then perceived as instrumental for achieving future goals such as attending a desired university or improving future career opportunities (Eccles, O'Neil, & Wigfield, 2005; House, 2009). Such activities derive utility value from those goals in the near or distant future (Wigfield & Eccles, 2002).

**Career aspirations in science (SCAP).** As Nagengast and Marsh (2012) proposed, career aspirations were defined as personal expectations and hopes of pursuing a career in a specific field (e.g., STEM) in the future. Their findings indicated the mediation of school-average ability effects on self-concept and career aspirations in science (Nagengast and Marsh, 2012). However, the present study focused on the relations between motivational beliefs in learning science and career aspirations in science at an individual level.

**Science self-efficacy (SSE) as related to career aspirations.** In terms of the definition of self-efficacy, SSE states clearly students' beliefs in their abilities to achieve a goal or overcome difficult tasks in science domain. Given recent empirical studies, students tend to have higher science attainments (Mohammadpour, 2013), have a more positive expectancy toward achieving in science (Coutinho & Neuman, 2008), place more value on science, and have a higher level of career aspirations in science when they are more self-confident in learning science (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001).

**Science self-concept (SSC) as related to career aspirations.** SSC is students' perceptions of their science abilities and their feelings of self-worth associated with this ability to do well in science (Wilkins, 2004). SSC was a significant predictor of pursuing post-school studies in STEM and a potential predictor of occupational aspirations in STEM (House, 2009; Jansen, Schroeders, & Lüdtke, 2014; Taskinen, Schütte, & Prenzel, 2013).

**Intrinsic value in learning science (IVS) as related to career aspirations.** The key role of IVS, embedded in several motivational theories, was highlighted in course selection in upper secondary education (Nagy, Trautwein, Baumert, Köller, & Garrett, 2006). The reports of TIMSS 2007 suggested that science achievement was higher among students who were more interested in science and perceived science as an enjoyable, valuable, and important subject for success in school and for their future careers (Martin, Mullis, & Foy, 2008).

**Instrumental motivation in learning science (IMS) as related to career aspirations.** IMS was an important predictor of course selection, career choice, and achievement for adolescents (House, 2009; Wigfield & Eccles, 2002). Students, who believed that schoolwork was important and valuable even though it was not inherently pleasurable, kept on doing the school work and reported high attainments (Green, Liem, Martin, Colmar, Marsh, & McInerney, 2012). IMS enhanced not only students' motivation in learning science, but also their subsequent performances in careers (Eccles, O'Neil, & Wigfield, 2005; Miller & Brickman, 2004).

Previous studies emphasized on the significant associations of students' science achievements with motivation beliefs in learning science such as SSC, SSE, IVS and IMS (Bryan, Glynn, & Kittleson, 2011; Jansen, Schroeders, & Lüdtke, 2014; Martin, Mullis, & Foy, 2008; Osborne, Simon, & Collins, 2003). However, little has been known about the direct and indirect effects of students' motivation beliefs in learning science such as SSE, SSC, IVS, and IMS on students' career aspirations in science with introduction of IMS as a mediator. In this study, I hypothesized a concept framework (see Figure 1) and employed a structural equation modeling approach to further investigate the mediation effects of IMS and the direct and indirect associations between motivational beliefs and career aspirations in science.

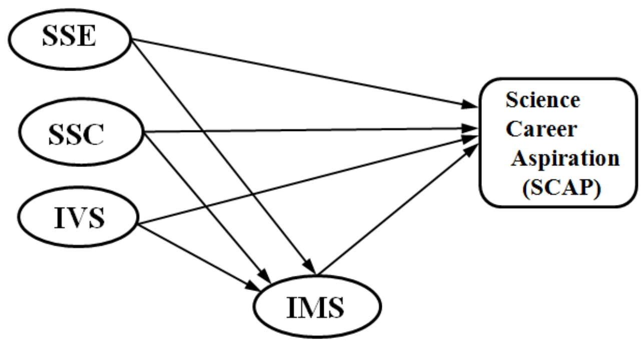


*Figure 1.* Conceptual framework of links between science self-belief motivation and science career aspirations.

*Note.* SSE = science self- efficacy; SSC = science self-concept; IMS = instrumental motivation in learning science; IVS = intrinsic value of science;

## Research Questions

Theoretical and empirical literature suggests that the investigation of motivational beliefs in science learning should take into account the direct and indirect effects of motivational beliefs (Marsh & O'Mara, 2008). Mediation effects on the associations between predictors (i.e., SSE, SSC, IVS, and IMS) and career aspirations (i.e., SCAP) always attract research attention (Tofighi & Thoemmes, 2014). Three topics of inquiry were addressed in the current study:

(1) Are there significant relations among motivational beliefs such as SSE, SSC, IVS, and IMS? Are there different relationships among motivational beliefs of adolescents in America and Singapore?

(2) Are adolescents’ motivational beliefs in learning science (i.e., SSE, SSC, IVS, and IMS) significantly related to their science career aspirations (i.e., SCAP)? Does the association vary in America and Singapore?

(3) To what extent do adolescents' IMS mediate the association between students' science career aspirations and motivational beliefs such as IVS, SSC, and SSE? Do the mediation effects vary in America and Singapore?

## Significance

The present study employed secondary data from TIMSS 2011 science reports in America and Singapore. Compared to 2007 TIMSS, students' science attitude scales from 2011 TIMSS included eight new items used in this study. The contributions of new items helped to better understand students' attitudes towards science in two nations. In contrast to previous research (Yu, 2012; Louis & Mistele, 2012), the present study clarified that nine items measuring students' confidence in learning science scaled two factor constructs such as self-efficacy and self-concept. Furthermore, this study investigated the mediation effects of adolescents' motivational beliefs in learning science on students' science career aspirations. The findings contributed to extend the knowledge of the associations between adolescents' motivational beliefs in learning science and science career aspirations. Collectively, the present study provided insightful information helping science educators to understand the influences of motivational beliefs on adolescents' learning science and career aspirations in two nations. This study also provided solid evidence for educators seeking an appropriate approach to promote adolescents' motivation in learning science and pursuing science careers.

## Methods

### Participants

The present study utilized the secondary data obtained from the TIMSS 2011 international database which was published by the National Center for Education Statistics. The data consist of students' responses to the questionnaires of student background and attitudes toward science.

Totally, 8,915 American eighth grade students and 5,746 Singaporean eighth graders are selected as participants in this study.

## Measures

**TIMSS 2011 Questionnaire.** TIMSS 2011 administered a student background questionnaire collecting data on student demographic characteristics, self-perceptions and attitudes toward science, home environment support, school climate and resources for teaching science, as well as teacher preparation and classroom instruction. Twenty items used in this study were drawn from student responses to questions about their perceptions and attitudes toward learning science. Student responses to the attitudinal items were measured using a four-point Likert scale. Participants may “disagree a lot,” “disagree a little,” “agree a little,” and “agree a lot” with each questionnaire item (coded from 4 to 1 respectively). For the present analyses, all selected items were reverse scored except negative attitude such as “science is boring”. Therefore, higher values represent higher and positive attitudes toward science. One item (i.e., BSBS19N) responding to the statement “How much do you agree that you would like a job that involves using science?” was chosen as an outcome variable, named as science career aspirations (SCAP). The outcome variable was recorded as a dichotomous variable (i.e., 0 = Disagree a lot, Disagree a little, and Agree a little; 1 = Agree a lot) in order to distinguish the strongly established career aspirations from wavering expectancy for pursuing science career. The interclass correlation coefficient (ICC) of SCAP was measured using SPSS 24. The ICC of SCAP in U.S. and Singaporean were .012 and .011, respectively. This indicates that school-level influence on students’ career aspirations was neglected.

***Attitude toward science scales.*** The total of 20 items comprised of three scales developed to measure eighth-grade student motivational constructs: intrinsic value (i.e., like learning science), self- beliefs (i.e., confidence in learning science), and utility value (i.e., value science) (Martin, Mullis, Foy, & Stanco, 2012). All observed variables were categorical.

Science attitude scales of TIMSS 2011 such as intrinsic value and utility value are constructive components of students' subjective task values which are important constructs of expectancy-value model of motivation (Eccles, O'Neil, & Wigfield, 2005). In a word, science attitude scales of TIMSS 2011are relevant to expectancy-value theory of motivation.

***Like Learning Science (i.e., IVS).*** Through engaging in an activity, the personal enjoyment or pleasure one experiences composes an intrinsic value construct (Eccles, O'Neil, & Wigfield, 2005). As the pursuit of enjoyment and interesting activities, the constructs of interest (e.g., item 17A states"I enjoy learning science") and positive affect (e.g., item 17Estates "I learn many interesting things in science") are closely related (Martin, Mullis, Foy, & Stanco, 2012; Hofer, 2010).

***Value Science (i.e., IMS)***. Students' perceptions of science utility for their present and future endeavors were defined as instrumental motivations: "the value of a task acquires because it is instrumental in reaching a variety of long- and short-range goals" (Eccles, O'Neil, & Wigfield, 2005, p. 239). For instance, item 19L states "I need to do well in science to get into the University of my choice", that indicated the enrollment of a desired university was the future reward of good science attainments.

***Confidence in Science (i.e., SSE and SSC).*** In light of expectancy-value theory, an individual's confidence in science is closely related to the ability beliefs in science which might be related to self-concept (Osborne, Simon, & Collins, 2003). Nine items measuring students' confidence in learning science were considered as one latent construct such as science self-concept in previous studies (Yu, 2012; Louis & Mistele, 2012). In terms of the comparisons between self-efficacy and self-concept (see Table 1), for instance, item 19C ("Science is not my strength"), indicating student judgment of the competence in learning science, was loaded in the latent construct of science self-concept. However, item 19D ("I learn thing quickly in science"), expressing student confidence in learning science, scaled a self-efficacy latent construct (Bong & Skaalvik, 2003). The factor analysis in this study aided to clarify that nine items measuring students' confidence in learning science scaled two factor constructs such as science self-efficacy and science self-concept.

Table 1.

*Comparisons among academic self-efficacy, academic self-concept, and instrumental motivation*

| Comparison dimensions | Academic self-concept | Academic self-efficacy | Instrumental motivation |
|---|---|---|---|
| Working definition | Knowledge and perceptions about oneself in achievement situations | Convictions for successfully performing given academic tasks at designated levels | Desire to obtain something practical or rewarding |
| Central element | Perceived competence | Perceived confidence | |
| Composition | Cognitive and affective appraisal of self | Cognitive appraisal of self | |
| Nature of competence evaluation | Normative and ipsative | Goal-referenced and normative | |
| Judgment specificity | Domain-specific | Domain-specific and context-specific | No |
| Time orientation | Past-oriented | Future-oriented | Future-oriented |
| Temporal stability | Stable | Malleable | Malleable |
| Predictive outcomes | Motivation, emotion, and performance | Motivation, emotion, cognitive and self-regulatory processes, and performance | Motivation, emotion |

*Note.* Adapted from (Bong & & Skaalvik, 2003; Eccles, O'Neil, & Wigfield, 2005)

## Data analysis

All data were analyzed utilizing SPSS 24 (IBM) and Mplus 7.0 (Muthén & Muthén, 2010). Data analysis was conducted in a step-wise fashion, starting with weights, missing value, data management, descriptive statistics, principle axis factor analysis (FA), exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and structural equation modeling (SEM). The weighted least squares mean variance (WLSMV) estimator (Finney & DiStefano, 2006) and theta parameterization were employed in the present study.

**Weights.** As the probability of selection sample units are not equal in the multistage cluster sampling design, sampling weights are used following the recommendations from the TIMSS users' guide to avoid bias in the estimated parameters (Asparouhov, 2005; Martin, Mullis, Foy, & Stanco, 2012). In this study, the house weight (HOUWGT) was used as the student-level weighting variable.

**Missing value.** In the present study, the highest percentage of missing data was 0.6% on the student level. That the small portion of data (i.e., 5% or less) is randomly missing in a large data set is not serious (Tabachnik & Fidell, 2007). Therefore, listwise deletion was conducted to remove cases where data were missing or there was no response. Finally, the American sample consisted of 8,470 students and the Singaporean subpopulation was 5,587.

**Factor analysis with polychoric correlation matrix**

Factor analysis is an important analytic tool for validity, reliability, and item analysis. However, common factor analysis and principal components analysis produce meaningful results only if the data are truly continuous and also multivariate normal. In this study, most data from TIMSS items adapted to a four-point scale cannot meet these common requirements. Alternatively, factor analysis using polychoric matrices can examine the relations among latent variables that are assumed to underlie the response data and to be continuous and normally distributed (Holgado-Tello, Chacón-Moscoso, Barbero-García, & Vila-Abad, 2010).

**Exploratory factor analysis (EFA) and principle axis factor analysis (FA).** The EFA program was employed to pull out the polychoric correlation matrix using Mplus 7.0 with the weighted least square mean variance (WLSMV) as an estimator. Since data involving humans are correlated, oblique rotation in exploratory factor analysis is recommended to obtain a set of relevant factors (Field & Filanosky, 2009). After getting the polychoric correlation matrices, principle axis factor (FA) analysis was conducted to assess the dimensionality of students' science attitude scales using SPSS 24. Eigenvalues, factor plot, and pattern matrix were used to measure the amount of variation which was explained by each component.

**Confirmatory factor analysis (CFA).** CFA was conducted to further examine and confirm the relationship between item and factor, and the factor structure of observed scores. When both EFA and CFA are conducted using data from the same sample, researchers are required to split the data into two halves (Johnson & Stevens 2001; Brown, 2006). Therefore, the data collected from 8,470 American students and 5,587 Singaporean students were split randomly and analyzed separately. The first half of the data was utilized for EFA with SPSS 24 and the second half of the data was used in the SEM based on CFA.

## Structural Equation Modeling (SEM)

SEM is a multivariate statistical approach that examines both the measurement and structural components of a model by testing the relationships among multiple independent and dependent constructs (Geffen, Straub, & Boudreau, 2000; Flora & Curran, 2004). Firstly, model specification began with identifying the measurement model components such as unobservable (latent) variables and indicators (i. e., item) which were linked with a set of hypotheses (Haenlein & Kaplan, 2004). And then, CFA was conducted to further examine and confirm the relationships among latent variables (i.e., factor). Due to the categorical and ordinal nature of items, WLSMV was employed as the estimation method (Finney & DiStefano, 2006). The reliability coefficients for factor variables were estimated by McDonald's Omega (1985, 1999) which indicated the ratio of the true variance estimated by a factor analysis over the variance of a composite.

To determine the fit of the measurement model, several fit indices were focused: the Chi-square test, the Comparative Fit Index (CFI) (Jöreskog & Sörbom, 1981; Hu & Bentler, 1999), Tucker-Lewis index (TLI) (Tucker & Lewis, 1973; Hu & Bentler, 1999), and the root mean square error of approximation (RMSEA) (Jöreskog & Sörbom, 1981). If the data did not fit the model well, the initial measurement model would be modified appropriately (Steiger, 1990).

The second step was conducted to test structural modeling by performing CFA procedures that examined the relevant fit of dependent relationships between the latent constructs of a model. The final structural model would adequately fit the data.

**Tests of mediation**

A mediating role can be determined using Baron and Kenny's (1986) criteria. In this study, for instance, the mediating test for American students' instrumental motivation involved three variables: science self-concept (independent variable), instrumental motivation (potential mediator), and science career aspiration (dependent variable). Test 1 estimates a model in which only science self-concept predicts science career aspiration; Test 2 examines a model in which only instrumental motivation in science predicts science career aspiration; Test 3 estimates a model in which only science self-concept predicts instrumental motivation in science; and Test 4 assesses the reduction in the path from science self-concept to science career aspiration with the introduction of instrumental motivation as a mediator. If Test 1, Test 2, and Test 3are significant, Test 4 would indicate that instrumental motivation partially mediate the path from science self-concept to science career aspiration and the total effects are equal to (Test 1 + Test 2 * Test 3). If

Test 1 is not significant, instrumental motivation fully mediate the path from science self-concept to science career aspiration and the total effects are equal to (Test 2 * Test 3). If each of Test 2 and Test 3is not significant, no mediation could work through instrumental motivation.

## Results

This study was designed to examine the relationships between student motivational beliefs in learning science (i.e., SSE, SSC, and IMS) and science career aspirations. The results are presented in the following sections as: (1) Preliminary results including demographics of the sample, descriptive statistics of selected items, factorial validity analysis, and latent construct reliability; (2) The results of structural equation modeling (SEM) including measurement model evaluation, structural model evaluation, matrix representation of mediation model, and mediation effects; (3) Summary of results to address research questions.

### Preliminary results

**Demographic characteristics of the Sample.** To ensure that the same participants' responses were measured, the two data files (i.e., student data file and school data file) were input into SPSS 24 and merged by identifying and matching school as well as student ID numbers. The sample comprised of American eighth grade students (N = 8,915) nested in 443 schools and Singaporean eighth graders (N = 5,746) nested in 160 schools who participated in the TIMSS test in 2011. About 49.1 percent of American eighth grade participants were girls and 50.9 percent were boys. Their average age was 14.2 and 90.4 percent of them reported that they spoke English in their homes. In Singapore, 49.5 percent of eighth grade participants were girls, and 50.5 percent were boys. Their average age was 14.4 and 56.2 percent of them reported that they spoke English (the language of the administrated test) in their homes.

**Descriptive statistics of selected variables.** To address the research questions, 20 items scaling student attitudes toward learning science were selected from the TIMSS, 2011, science reports of eighth grade students in America and Singapore. The statistic characteristics of variables, such as mean and standard deviation using routine procedures of SPSS 24, were summarized (see Table 2). Students' interests in learning science (IVS) included items 17A through 17F and its reliability was .872 (USA) and .882 (SGP). Items 19A through 19I scales measured students' confidence in learning science with reliability was .880 (USA) and .889 (SGP). Items 19J through 19M measured students' value of science (IMS) with reliability was .863 (USA) and .851 (SGP).

Table 2.

*Statistics description of 8$^{th}$ grade students' attitudes toward learning science in America and Singapore*

| TIMSS2011 Questionnaire item | Description | Mean USA/ SGP | Std. Deviation USA/ SGP | Cronbach's Alpha USA/ SGP |
|---|---|---|---|---|
| **Observed variables** | | | | |
| **Students like learning science (Intrinsic value of science, IVS)** | | | | |
| How much do you agree with these statements about learning science? | | | | .872/.882 |
| BSBS17A | I enjoy learning science | 1.97/3.25 | .96/.78 | |
| BSBS17B | I wish I did not have to study science | 2.73/1.96 | 1.04/.93 | |
| BSBS17C | I read about science in my spare time | 3.24/2.52 | .94/ .93 | |
| BSBS17D | Science is boring | 2.72/1.99 | 1.04/.91 | |
| BSBS17E | I learn many interesting things in science | 1.73/3.41 | .87/ .72 | |
| BSBS17F | I like science | 2.02/3.17 | 1.00/ .83 | |
| **Students Confidence in Science (self-concept (SSC) and/or self-efficacy (SSE))** | | | | |
| How much do you agree with these statements about science? | | | | .880/.889 |
| BSBS19A | I usually do well in science | 1.69/2.89 | .81/.83 | |
| BSBS19B | Science is more difficult for me than for many of my classmate | 3.08/2.19 | .92/.87 | |
| BSBS19C | Science is not one of my strengths | 2.77/2.38 | 1.03/.97 | |
| BSBS19D | I learn things quickly in science | 2.00/2.80 | .91/.84 | |
| BSBS19E | Science makes me confused and nervous | 3.13/2.23 | .92/.90 | |

Table 2. (Continued)

*Statistics description of 8th grade students' attitudes toward learning science in America and Singapore*

| | | | | |
|---|---|---|---|---|
| BSBS19F | I am good at working out difficult science problems | 2.30/2.47 | .97/.86 | |
| BSBS19G | My teacher thinks I can do well in science <programs/classes/lessons> with difficult materials | 2.04/2.23 | .96/.90 | |
| BSBS19H | My teacher tells me that I am good at science | 2.22/2.47 | 1.03/.86 | |
| BSBS19I | Science is harder for me than any other subject | 3.13/2.13 | .99/.94 | |
| **Students Value Science (Instrumental value of science, IMS)** | | | | .863/.851 |
| How much do you agree with these statements about science? | | | | |
| BSBS19J | Learning science will help me in my daily life | 1.91/3.39 | .93/.70 | |
| BSBS19K | I need science to learn other school subjects | 2.23/3.00 | 1.00/.85 | |
| BSBS19L | I need to do well in science to get into the <university> of your choice | 1.70/3.31 | .90/.79 | |
| BSBS19M | I need to do well in science to get the job I want | 2.04/3.12 | 1.06/.89 | |
| BSBS17G | It is important to do well in science | 1.59/1.59 | .82/.82 | |
| **Outcome variable** | | | | |
| Science career aspiration (SCAP) | | | | |
| BSBS19N | How much do you agree that you would like a job that involves using science? | 2.46/2.73 | 1.14/1.00 | |

**Factorial validity test of student confidence in learning science.** The nine-item scale of student confidence in learning science was subjected to exploratory factor analysis (EFA) (TYPE = 1 2;) using weighted least square mean variance (WLSMV) estimation and Oblique rotation by Mplus 7.0. The model fit indices were summarized in Table 3. Model fit indices presented that two factors' model better fit the data than one factor model.

The nine-item scale of student confidence in learning science was further subjected to principle axis factor analysis (FA) without rotation using SPSS 24. Inspection of the correlation

Table 3.

*Comparison of fit indices between the one factor model and the two factors model of eighth grade students' confidence with learning science in TIMSS 2011*

| Model | Chi-Square Value | Degrees of Freedom (*P*-Value) | RMSEA Estimate | 90 Percent C.I. (Probability RMSEA <= .05) | CFI/ TLI | SRMR Value |
|---|---|---|---|---|---|---|
| ***America*** | | | | | | |
| One factors | 9622.540 | 27 (0.0000) | 0.205 | 0.201 0.208 (0.000) | 0.915/ 0.887 | 0.107 |
| Two factors | 1641.172 | 19 (0.000) | 0.100 | 0.096 0.105 (0.000) | 0.986/ 0.973 | 0.021 |
| ***Singapore*** | | | | | | |
| One factors | 7638.751 | 27 (0.000) | 0.225 | 0.220 0.229 (0.000) | 0.923/ 0.897 | 0.099 |
| Two factors | 1660.961 | 19 (0.000) | 0.124 | 0.119 0.129 (0.000) | 0.983/ 0.969 | 0.021 |

matrix revealed the presence of many coefficients was above moderate correlation (> .30) (Cohen,1988). The Kaiser-Meyer-Oklin (KMO) value was .889 (Singapore) and .906 (America), exceeding the recommended value of .60 (Kaiser, 1970, 1974), and Bartlett's Test of Sphericity (39520/ 21034 for America/ Singapore) reached statistical significance, supporting the factorability of the correlation matrix (Bartlett, 1950). However, FA showed the presence of two components with eigenvalues exceeding 1.0, illustrating 68.90% of American variance and 71.56% of Singapore variance, respectively. The scree plot also revealed a clear break after the first two components. On this basis, I hypothesized that not all scale items would measure a single latent construct.

Therefore, based upon above examinations of FA and EFA, the measures of student confidence in learning science scaled two latent constructs: (1) items 19B, 19C, 19E, and 19I measured science self-concept latent construct (named SSC), (2) items 19A, 19D, 19F, 19G, 19H scaled science self-efficacy construct (named SSE) (see Table 1; Bong & Skaalvik, 2003).

**Latent construct reliability of student attitudes toward learning science.** The test of the constructive reliability of four potential latent variables such as IVS, SSE, SSC, and IMS was conducted by the polychoric correlation matrix and FA with promax rotation. The summary of FA outputs in Table 4 presented four components with eigenvalues exceeding 1.0, illustrating 75.27% of American variance and three components with eigenvalues exceeding 1.0, illustrating 71.74% of Singaporean variance, respectively. The scree plot also revealed a clear break after the first two components. On this basis, I hypothesized that all scale items would measure different latent constructs in two nations.

Table 4.

*Comparison of initial eigenvalues of factor constructs of American and Singaporean students' attitude toward science learning*

| | America | | | | Singapore | | | |
|---|---|---|---|---|---|---|---|---|
| | Initial Eigenvalues | | | Rotation Sums Total | Initial Eigenvalues | | | Rotation Sums Total |
| Factor | Total | % of Variance | Cumulative % | | Total | % of Variance | Cumulative % | |
| 1 | 10.18 | 50.90 | 50.90 | 6.48 | 10.80 | 54.01 | 54.01 | 10.80 |
| 2 | 2.54 | 12.70 | 63.60 | 6.38 | 2.29 | 11.46 | 65.48 | 2.29 |
| 3 | 1.19 | 5.92 | 69.52 | 8.42 | 1.25 | 6.26 | 71.74 | 1.25 |
| 4 | 1.15 | 5.75 | 75.27 | 7.66 | .90 | 4.48 | 76.23 | .90 |

*Note.* Factor analysis = Principal axis factoring; Rotation = Promax.

The pattern matrix of American students' science attitudes presented that 20 response items were definitely separated in four constructs, whereas Singaporean students' science attitudes were separated by three dimensions in a pattern matrix (see Table 5). Singaporean students' intrinsic values of science, such as items 17A, 17C, 17E, and 17F were particularly

Table 5.

*FA Pattern Matrix of American and Singaporean students' attitude toward science learning*

| | America | | | | Singapore | | |
|---|---|---|---|---|---|---|---|
| | Factor | | | | Factor | | |
| Item | 1 | 2 | 3 | 4 | 1 | 2 | 3 |
| BSBS17A | -.007 | -.016 | **.856** | .111 | ***.439*** | ***.338*** | .209 |
| BSBS17B | ***.319*** | .050 | ***.654*** | -.206 | **.814** | .180 | -.155 |
| BSBS17C | -.173 | .064 | **.578** | .169 | .109 | ***.322*** | ***.307*** |
| BSBS17D | .241 | -.018 | **.804** | -.191 | **.785** | .216 | -.149 |
| BSBS17E | -.113 | .059 | **.774** | .092 | ***.318*** | ***.451*** | .100 |
| BSBS17F | -.029 | -.027 | **.914** | .096 | ***.443*** | ***.367*** | .210 |
| BSBS17G | -.042 | **.634** | .196 | .060 | .071 | **.805** | -.068 |
| BSBS19A | ***.290*** | .069 | .041 | ***.549*** | ***.324*** | .002 | ***.599*** |
| BSBS19B | **.884** | .003 | -.083 | .034 | **.900** | -.209 | .029 |
| BSBS19C | **.749** | -.007 | .083 | .070 | **.773** | -.114 | .148 |
| BSBS19D | *.224* | .000 | .140 | **.590** | *.292* | .045 | **.582** |
| BSBS19E | **.802** | -.003 | .009 | -.009 | **.854** | -.161 | -.022 |
| BSBS19F | .108 | -.016 | .096 | **.682** | .110 | .001 | **.762** |
| BSBS19G | -.041 | .007 | -.078 | **.916** | -.124 | -.015 | **.957** |
| BSBS19H | -.056 | -.003 | .012 | **.827** | -.139 | -.048 | **.979** |
| BSBS19I | **.869** | -.009 | -.011 | -.007 | **.955** | -.164 | -.051 |
| BSBS19J | -.055 | **.745** | .179 | .007 | .026 | **.818** | -.024 |
| BSBS19K | -.085 | **.781** | .041 | .023 | -.203 | **.813** | .045 |
| BSBS19L | .085 | **.939** | -.156 | .003 | -.122 | **.948** | -.065 |
| BSBS19M | .063 | **.878** | -.056 | -.058 | -.150 | **.862** | .018 |

*Note.* Extraction Method: Principal Axis Factoring. Rotation Method: Promax with Kaiser Normalization. Bold = high factor loadings. Italic = cross loading.

interspersed in three constructs. However, item 17B and 17D were clearly loaded in the same dimension with item 19B and 19C. Therefore, six items (items 17A through 17F) responding to student intrinsic values of science were not retained in this study because they could not definitely scale one latent construct for the Singaporean subpopulation.

According to the pattern matrix and factor loadings of the other three latent predictors (i.e., SSC, SSE, and IMS), I found that: (1) items 19B, 19C, 19E, and 19I showed higher standardized factor loadings than .74 and they were retained in the first dimension; (2) the factor loadings of 19J, 19K, 19L, and 19M were higher than .70 and they were grouped in the second dimension; (3) item 17G (stating "*It is important to do well in science*") implying an extrinsic motivation (Deci & Ryan, 2000) was identified in the second construct with higher loading than .63 and .81 using the American and Singaporean dataset, respectively; (4) items 19F, 19G, 19H (with higher factor loadings than .68) and 19D (with low loading, .58) were retained in third dimension; (5) item 19A had higher factor loadings than 0.30 in two constructs (Tabachnick, Fidell, & Osterlind, 2007), and that indicated the discriminate validity of 19A was not satisfied. Therefore, item 19A was not retained in further analysis.

In sum, 13 items were chosen to measure three latent constructs of students' attitudes toward science and to explore the direct and indirect effects between predictors such as SEE, SSC and the outcome variable (i.e., SCAP), using a structural equation modeling approach.

**Structural equation modeling (SEM)**

**Measurement model evaluation.** Following the routine procedures, the measurement model of three latent factors (i.e., SSE, SSC, and IMS) with 13 categorically observed variables was evaluated using a CFA with WLSMV estimate method.

The outputs of CFA indicated that the measurement models of three respective latent factors (i.e., SSE, SSC, and IMS) were well fitted data with goodness-of-fit indices: (1) $\chi^2$ = 604.78 (*df* = 49, *p* <.001), CFI = .98, TLI = .98, RMSEA = .07, for the American subpopulation; (2) $\chi^2$ = 795.82 (*df* = 50, *p* <.001), CFI = .99, TLI =.98, RMSEA = .07, for the Singaporean

Table 6.

*Summary of Standardized Estimates of observed variables and McDonald's ω*

| | America | | | | Singapore | | | |
|---|---|---|---|---|---|---|---|---|
| | Estimate | S.E. | Residual variance | ω | Estimate | S.E. | Residual variance | ω |
| IMS BY | | | | .917 | | | | .910 |
| 17G | .804 | .006 | .354 | | .801 | .008 | .358 | |
| 19J | .864 | .004 | .254 | | .826 | .007 | .317 | |
| 19K | .791 | .005 | .374 | | .720 | .008 | .482 | |
| 19L | .864 | .005 | .254 | | .887 | .005 | .214 | |
| 19M | .827 | .005 | .316 | | .851 | .006 | .275 | |
| SSC BY | | | | .905 | | | | .899 |
| 19B | .842 | .005 | .291 | | .844 | .005 | .288 | |
| 19C | .871 | .005 | .242 | | .874 | .006 | .236 | |
| 19E | .794 | .006 | .370 | | .760 | .007 | .422 | |
| 19I | .849 | .005 | .280 | | .844 | .006 | .287 | |
| SSE BY | | | | .896 | | | | .916 |
| 19D | .882 | .004 | .222 | | .880 | .005 | .225 | |
| 19F | .830 | .005 | .312 | | .853 | .005 | .273 | |
| 19G | .813 | .005 | .339 | | .856 | .005 | .267 | |
| 19H | .781 | .005 | .390 | | .832 | .005 | .307 | |

*Note*. Two-Tailed *p* value : .0000

subpopulation. Under standardized conditions, the estimates of observed variables and McDonald's Omegas were summarized in Table 6. For the American subpopulation, the range of R- square of observed variables for factor SSE, SSC, and IMS were estimated from .629 to .762,

.626 to .746, and .610  to .778, respectively. For the Singaporean subpopulation, the range of R-square of observed variables were estimated from .578 to .712 for SSC, .693 to .775 for SSE, and .518 to .786 for IMS. The McDonald's Omega of each latent factor was: (1).896 (SSE), .905 (SSC), SSC (.905), IMS (.917) for American subpopulation, (2) SSE (.916), SSC (.899), IMS (.910) for Singaporean subpopulation. Each latent construct showed a high reliability.

Collectively, 13 items were evidently loaded in three constructs with factor loadings from .70 to .89. The factor loadings in CFA followed a benchmark of .70 or higher loading value in order to confirm that the constructs was comprised of valid indicators (Chin, 1998).  However, "factor loadings must be interpreted in the light of theory, not by arbitrary cutoff levels" (Raubenheimer, 2004, p. 61). According to the model modification, items 19L and 19M were found to be extremely correlated in the model. Item 19M was not retained (Steiger, 1990). Therefore, a total of 12 items were selected for further model analysis.

The summary of correlation coefficients among motivational beliefs in learning science aided to address the first research question.

***The relations among three motivational beliefs in science learning.*** The results of SEM measurement model (see Table 9) presented correlations between motivational beliefs in

Table 7.

*The relations among motivational self-beliefs in learning science in America and Singapore*

| | America | | | Singapore | | |
|---|---|---|---|---|---|---|
| Correlation | Estimate | S.E. | *P*-Value | Estimate | S.E. | *P*-Value |
| SSC WITH IMS | .327 | .016 | .000 | .414 | .019 | .000 |
| SSE WITH | | | | | | |
| IMS | .626 | .012 | .000 | .581 | .016 | .000 |
| SSC | .686 | .011 | .000 | .735 | .011 | .000 |

learning science in two countries. Singaporean students' IMS was moderately related to SSC and to SSE with .414 and .581 correlations (Cohen, 1988). Singaporean adolescents' SSC was strongly related their SSE with a .735 correlation. On the other hand, American students' SSE was highly related to their IMS, with a large correlation .626, and it was also strongly related to their SSC, .686. However, American students had the lowest correlation between their SSC and IMS, .327. In conclusion, there were significant relations among motivational beliefs such as SSE, SSC, and IMS. The relationships among motivational beliefs of adolescents were different in America and Singapore.

**Structural model evaluation.** The final solution with reporting both measurement and structural parts of the model was presented in Figure 2. Models MA (for the American subpopulation) and MS (for the Singaporean adolescents) involved the freeing of the following structural paths: (i) science self-efficacy to science career aspiration, (ii) science self-concept to science career aspiration, (iii) science self-concept to instrumental motivation, (iv) instrumental motivation to science career aspiration, and (v) science self-efficacy to instrumental motivation. The goodness-of-fit index values indicated a adequate fit to the model, as depicted by the following: (1) MA: $\chi^2 = 880.015$ ($df = 60$) ($p <.001$), TLI = .977, CFI = .982, RMSEA = .057 (90% CI = .054; .060), $p < .001$; (2) MS: $\chi^2 = 649.219$ ($df = 60$) ($p < .001$), TLI = .983, CFI = .987, RMSEA = .059 (90% CI = 0.055; 0.063), $p <.001$. In sum, this structural model adequately fit data.

The summary of standardized direct effects, total indirect effects, and total effects for models MA and MS (outputs from Mplus 7.0) was presented in Table 8 and 9.The findings of this research verified diverse paths through which $8^{th}$ grade students' science self-beliefs associated with their science career aspirations. Most of the links in the postulated structure were empirically substantiated. The summary of direct effects from three structural paths such as: (i)

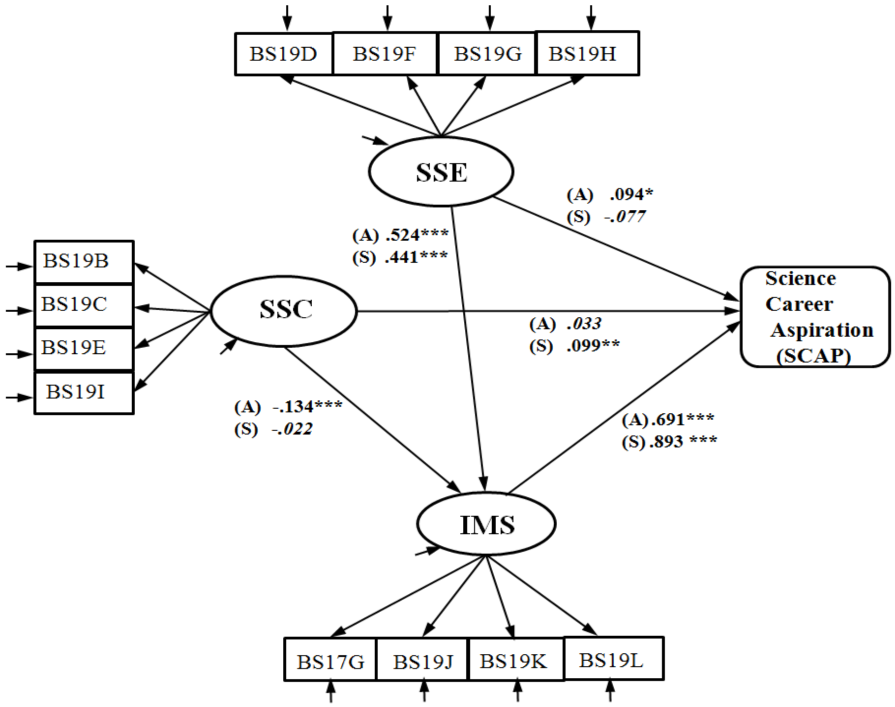


*Figure 2.* Final solution with reporting both measurement and structural parts of a model. *Note.* SSC = science self-concept; SSE = science self- efficacy; IMS = instrumental motivation in learning science; IVS = intrinsic value of science. A = America; S = Singapore. *** ($p \leq 0.005$), ** ($p \leq 0.01$), * ($p \leq 0.05$), *Italic* ( $p > 0.05$).

science self-efficacy to science career aspirations, (ii) science self-concept to science career aspirations, (iv) instrumental motivation to science career aspirations, aided to address the second research question.

***Effects of motivational beliefs on career aspiration in science s.*** American students' science self-concept was not a significant predictor for their science career aspirations (i.e., direct effect = .033, $p > .05$). Their science self-efficacy was a significant but weak factor influencing on their career aspirations (i.e., direct effect = .094, $p < .05$). Therefore, the finding suggested those American adolescents' self-concept and self-efficacy in learning science had little chance

Table 8.

*Standardized direct and indirect effects of predictors and mediators on American students' science career aspiration*

| Model | Effects | Mediator | Direct effect (S.E.) | Total indirect effect (S.E.) | Specific indirect effect β /(S.E.) | Standardized total effect (S.E.) | Mediate effect (F/P) |
|---|---|---|---|---|---|---|---|
| | Effect from IMS to SCAP | | .691*** (.024) | | | .691*** (.024) | |
| MA | Effects from SSE to SCAP | IMS | .094* (.039) | .524 *** (.024) | SCAP IMS SSE .524*** / (.024) | .619*** (.028) | .456 (P) |
| | Effects from SSC to SCAP | IMS | *.033* (.029) | -.134*** (.017) | SCAP IMS SSC -.134*** /(.017) | -.101 *** (.028) | -.093 (F) |

*Note.* SSE= science self-efficacy; SSC= science self-concept; IMS= instrumental motivation in science learning; SCAP= science career aspirations; Model MA is a structural model presenting the direct and indirect effects of predictors (i.e., SSE and SSC) and mediators (i. e., IMS) on American students' science career aspiration. F = Full mediation effect; P = Partial mediation effect.

*** $p < 0.005$, ** $p < 0.01$, * $p < 0.05$, *Italic* = $p > 0.05$ (two-tailed testing of significance).

Table 9.

*Standardized direct and indirect effects of predictors and mediators on Singaporean students' science career aspiration*

| Model | Effects | Mediator | Direct effect (S.E.) | Total indirect effect (S.E.) | Specific indirect effect β /(S.E.) | Standardized total effect (S.E.) | Mediated effect (F/P) |
|---|---|---|---|---|---|---|---|
| | Effect from IMS to SCAP | | .893*** (.023) | | | .893*** (.023) | |
| MS | Effects from SSE to SCAP | IMS | -*.077* (.042) | .441 *** (.031) | SCAP IMS SSE .441*** / (.031) | .517 *** (.035) | .394 (F) |
| | Effects from SSC to SCAP | | .099** (.036) | -*.022* (.026) | | .078** (.036) | |
| | | IMS | | | SCAP IMS SSC -*.022* / (.026) | | |

*Note.* SSE= science self-efficacy; SSC= science self-concept; IMS= instrumental motivation in science learning; SCAP= science career aspiration; Model MA is a structural model presenting the direct and indirect effects of predictors (i.e., SSE and SSC) and mediators (i. e., IMS) on Singaporean students' science career aspiration. F = Full mediation effect; P = Partial mediation effect.

*** $p < 0.005$, ** $p < 0.01$, * $p < 0.05$, *Italic* = $p > 0.05$ (two-tailed testing of significance).

in stimulating low science career aspirations. Conversely, American adolescents' instrumental motivation for learning science statistically and significantly affected their aspirations to infuse science into their future jobs (i.e., direct effect = .691, $p < .005$).

Singaporean 8th grade students' science self-concept was a positive and significant predictor for their science career aspirations (i.e., direct effect = .099, $p < .05$), consistant with previous studies (Mohammadpour, 2013; Jocz, Zhai, & Tan, 2014). However, their science self-efficacy was not significantly related to their career aspirations. It's not surprising that Singaporean adolescents' instrumental motivation for learning science statistically and significantly affect their aspirations (i.e., direct effect = .893, $p < .005$) to look for jobs involving science in the future.

In sum, American adolescents' science self-efficacy and Singaporean students' science self-concept significantly predicted their science career aspirations, respectively. Adolescents' instrumental motivation in learning science statistically and significantly influenced their aspirations in two nations. However, the associations varied slightly between America and Singapore.

**Mediation effects.** In Table 8 and 9, the decomposition of the specific indirect effects shows the actual mediating paths. For instance, there were two specific mediation effects from model MA: (i) the specific indirect effect of science self-efficacy to instrumental motivation (i.e., $\beta = .524$, $p < .001$); (ii) the specific indirect effect of science self-concept to instrumental motivation (i.e., $\beta = -.134$, $p < .001$). For model MS, the specific mediating effect was the indirect effect of science self-efficacy to instrumental motivation (i.e., $\beta = .441$, $p < .001$). Whereas, the specific indirect effect of science self-concept to instrumental motivation was not significant (i.e., $\beta = -.022$, $p > .05$).

**Matrix representation of mediation model.** The mediation effects of American students' science self-concept, for instance, were estimated in the matrix representation of mediation model (Figure 2). The single-mediator model presented relations among a mediator (i.e., IMS), an independent variable (i.e., SSC), and a dependent variable (i.e., SCAP). IMS and SSC were measured by four observed variables, respectively.

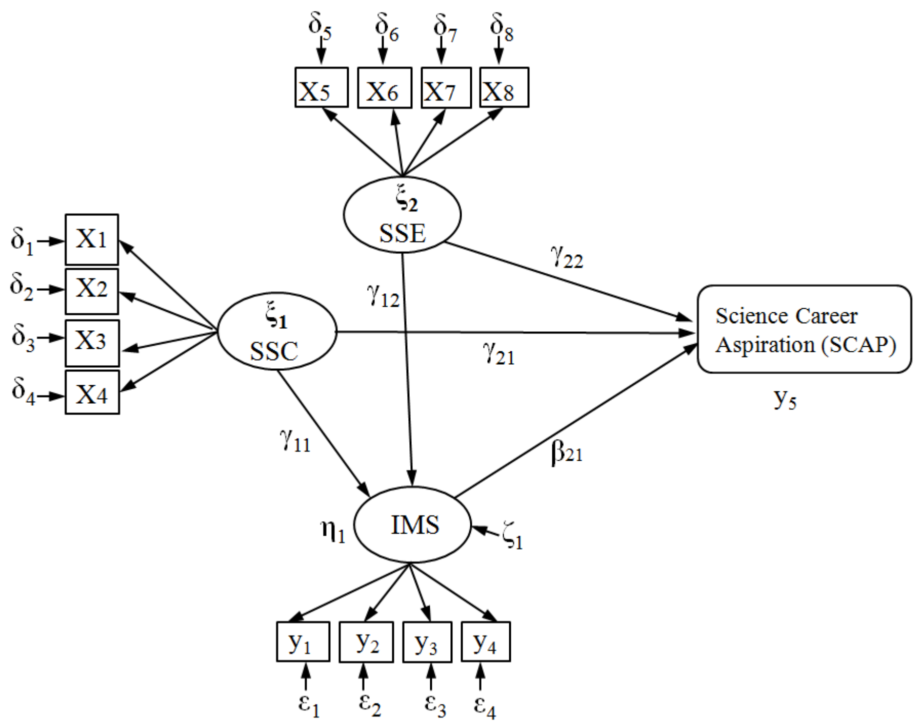


*Figure 3.* A single-mediator model with latent variables (each with four indicators) and a dichotomous outcome variable

*Note.* $X_1$ through $X_4$ representing BS19B, BS19C, BS19E, BS19I; $X_5$ through $X_8$ representing BS19D, BS19F, BS19G, BS19H; $y_1$ through $y_4$ representing BS17G, BS19J, BS19K, BS19L.

The relations between the independent variables (i.e., SSC), and the dependent variable (i.e., SCAP) are specified in the measurement relations as Equations 3.1 and

3.2:

$$X = \Lambda_x \xi + \delta; \Rightarrow \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \lambda_{X21} & 0 \\ \lambda_{X31} & 0 \\ \lambda_{X41} & 0 \end{bmatrix} [\xi_1] + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \end{bmatrix} \quad (3.1)$$

$$y = \Lambda_y \eta + \varepsilon; \Rightarrow \begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \lambda_{y21} & 0 \\ \lambda_{y31} & 0 \\ \lambda_{y41} & 0 \end{bmatrix} [\eta_1] + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \end{bmatrix} \quad (3.2)$$

The relations between the independent variables (i.e., SSC), the mediator (i.e., IMS), and the dependent variable (i.e., SCAP) are specified in the structural relations as Equations 3.3 and 3.4:

$$\eta = B\eta + \Gamma\xi + \zeta \quad (3.3)$$

$$\begin{bmatrix} \eta_1 \\ y_5 \end{bmatrix} = \begin{bmatrix} 0 \\ \beta_{21} \end{bmatrix} [\eta_1] + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \varepsilon_5 \end{bmatrix} \quad (3.4)$$

Where

$\eta$ is a vector representing the mediator (IMS) and the dependent variable (SCAP = $y_5$) in Figure 2;

$\eta_1$ is a vector representing the mediator (IMS) only;

B matrix is representing the relation between instrumental motivation (IMS) and science career aspirations (SCAP);

$\Gamma$ matrix is a vector representing the relations of science self-concept (SSC) to instrumental motivation (IMS) and science career aspirations (SCAP);

$\xi$ is a vector representing the independent variable;

$\xi_1$ represents science self-concept (SSC);

$\zeta$ is a vector representing variable residuals;

$\zeta_1$ indicates science self-concept (SSC) residuals;

$\gamma_{11}$ indicates the coefficient relating SSC and IMS;

$\gamma_{21}$ indicates the coefficient relating SSC and SCAP;

$\beta_{21}$ indicates the coefficient relating IMS and SCAP;

$\delta$ indicates observed variable ($x_1$ through $x_8$) residual;

$\varepsilon$ indicates observed variable ($y_1$ through $y_5$) residual;

Sum up, the total indirect effects of SSC on SCAP equals $\gamma_{21} + \gamma_{11}\beta_{21}$.

***Mediated effects on the links between career aspirations and motivational beliefs in science.*** The test for full or partial mediation effects was undertaken using Baron and Kenny's criteria (1986). The mediation test of American students' instrumental motivation involved: Test 1(the structural path from science self-concept to science career aspirations) was not significant (i.e., $\gamma_{21(A)} = .033$, $p > .05$); Test 2 (the structural path from instrumental motivation to science career aspirations) was significant (i.e., $\beta_{21(A)} = .691$, $p < .005$); Test 3 (the structural path from science self-concept to instrumental motivation) was significant (i.e., $\gamma_{11(A)} = -.134$, $p < .05$); Test 4 indicated the mediation role of instrumental motivation was full (i.e., $\gamma_{11(A)}\beta_{21(A)} = -.093$). With respect to science self-efficacy, the mediating effect of instrumental motivation was inspected: Test 1 (the structural path from science self-efficacy to science career aspirations) was statistically significant (i.e., $\gamma_{22(A)} = .094$, $p < .05$); Test 2 (the structural path from instrumental motivation to science career aspirations was statistically significant (i.e., $\beta_{21(A)} = .691$, $p < .005$); Test 3 (the structural path from science self-efficacy to instrumental motivation) was statistically significant (i.e., $\gamma_{12(A)} = .524$, $p < .001$); Test 4 was a reduction in the structural path effect (i.e., mediated effect = $\gamma_{22(A)} + \beta_{21(A)}\gamma_{12(A)} = .094 + .691 * .524 = .362$, $p < .001$). Given that the effect of science self-efficacy on science career aspiration remained statistically significant, the mediation role of instrumental motivation was partial.

Similarly, the mediating effect of Singaporean students' instrumental motivation was tested using the same criteria. Given that the direct effect of science self-efficacy to science full career aspirations did not remain significant, the mediation effect of instrumental motivation (i.e., mediated effect = $\beta_{21(S)}\ \gamma_{12(S)}$ = .893*.441= .394, $p < .001$). With respect to science self-concept, the mediation effect of instrumental motivation was tested. Given that the indirect effect of science self-concept to instrumental motivation did not remain significant, the mediation test did not pass Test 2. Therefore, Singaporean students' instrumental motivation did not mediate the link between science self-concept and science career aspirations.

Collectively, the above results of mediation effects of IMS contributed to address the third research question. American students' IMS partially and positively mediated the relationship between SSE and SCAP, whereas their IMS fully but negatively mediated the association between SSC and SCAP. On the other hand, Singaporean students' IMS fully and positively mediated the relationship between SSE and SCAP. However, their IMS did not play a significant mediating role on the link between SSC and SCAP.

## Discussion

The present study aims to investigate: (1) the inter-relations among three motivational beliefs such as science self-efficacy, science self-concept, and instrumental motivation, (2) the relationships between motivational beliefs and career aspirations in science, and (3) the mediation effects of instrumental motivation on the links between science self-efficacy or science self-concept and career aspiration in science. This section opens with the discussions of research findings and closes with the strengths and limitations of this study.

The previous summaries of results adequately addressed three research questions of this study. The discussion of findings in the present research is as follows. Firstly, different correlations among students' science self-efficacy, science self-concept, and instrumental motivation in two nations are consistent with previous empirical studies (Bong & Skaalvik, 2003; Marsh & O'Mara, 2008). Middle school students, for instance, who desire to obtain something practical or rewarding (i.e., instrumental motivation) (Husman & Lens, 1999), possess high perceptions of self (i.e., self-concept) and master their experiences (i.e., self-efficacy) to perform well at tasks. According to the comparisons of self-efficacy, self-concept, and instrumental motivation (see Table 1), one of characteristics of self-concept is past-oriented while the time orientations of self-efficacy and instrumental motivation are future. Eccles and her colleagues (2005) found that students' self-concept strongly related to subsequent math grades, whereas students' subjective task value constructs (i.e., instrumental motivation) strongly related to a new course enrollment plan or decision. Therefore, the inter-relations between science self-concept and instrumental motivation were lower than the correlations between science self-efficacy and instrumental motivation in two countries. On the other hand, those high correlations between science self-efficacy and science self-concept in two nations suggested that self-efficacy and self-concept might well be interchangeable concepts in science domain as same as in math domain (Pajares, 1996). Particularly, Singaporean adolescents presented the highest correlations between science self-efficacy and science self-concept due to their rigorous science trainings in their middle schools to obtain high science score and then to enroll in desired high schools (Jocz, Zhai, & Tan, 2014; Mohammadpour, 2013 ). In the long run, their successful science achievements (i.e., science scores) not only contribute to their high schools' enrollments but also bolster their competencies and confidences on learning science.

Secondly, those present analyses pointed to a picture where career aspirations in science were significantly and highly related to American students' science self-efficacy and Singaporean adolescents' science self-concept, respectively. According to the distinct characteristics between self-concept and self-efficacy (Bong & Skaalvik, 2003), for instance, Singaporean students possessing science self-concept usually come up to high performance goals in science. As they are confident on their past science performances, they persist in learning science and later looking for jobs involving in science (Mohammadpour, 2013). Conversely, American adolescents, who possess high science self-efficacy and mastery experiences, prefer planning and engaging in future science careers. Those findings were consistent with previous studies (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Carlone & Johnson, 2007) to clarify the contributions of students' positive self-beliefs in science to their persistence in learning science and pursuing science careers. Green and colleagues (2012) found other factors, such as science engagement at school, acted in conjunction with self-efficacy in science to influence the educational or subjective choices. That is an important step in the path to attaining those career aspirations in science (Cleaves, 2005; Taskinen, Schütte, & Prenzel, 2013). Other researchers proposed that students' competence could bolster their self-concept in science if their science performances were recognized by their teachers and parents (Aschbacher, Li, & Roth, 2010; Hazari, Sonnert, Sadler, & Shanahan, 2010; Ferry, Found, & Smith, 2000). In terms of present findings, it is advisable for American educators to shape adolescents' science career trajectories through two approaches: (1) properly promoting eighth grade students' science engagement at school in conjunction with emphasizing their mastery experiences in science; (2) appropriately expressing approvals and commendations for students' performances in science subjects.

Instrumental motivation is a major tool encouraging American and Singaporean students to pursue science careers, just as the fastest growing jobs in the world, such as engineering, require solid foundations in mathematics and science. It is not doubtful, both America and Singapore need more scientists and engineers in order to be competitive in the world. Yu (2012) suggested that instrumental motivation (i.e., ‘‘I need to do well in science to get the job I want’’) was the most significant motivator for American students. However, other perceptions concerning the role of science in daily life were not significant predictors for American adolescents (Yu, 2012). In this study, four indicators such as ‘‘science will help me in my daily life,’’ “I need science to learn other things,” “I need to do well in science to get into the university of my choice,” and “It is very important to do well in science” scaled adolescents’ instrumental motivation, which was significantly and strongly related to students’ perceived role of science in their daily life and educational desires. It is advisable that educators in America and Singapore balance the emphasis on the financial benefits of STEM and the value of science in daily life (Yu, 2012; Lips & McNeill, 2009) to encourage adolescents to enjoy learning science.

Furthermore, instrumental motivation is not only a key predictor for career aspirations in science but also an important mediator. In the view of time orientations of science self-concept and instrumental motivation (see Table 1), for instance, students possessing high science self-concept prefer good academic scores and performances happened in past semester, while students with their instrumental motivation will look forward to new science course enrollments in next semester (Eccles, O’Neill, & Wigfield, 2005). Therefore, students’ instrumental motivation could not mediate the link between science self-concept and career aspirations in science due to different orientations. On the contrast, adolescents’ science self-efficacy provides their mastery experiences for future-oriented performances and students’ instrumental motivation tends to design future performances. Therefore, it’s acceptable that students’ instrumental motivation plays the role of partial or full mediation on the link between science self-efficacy and career aspirations in science. American students' instrumental motivation partially and positively mediated the relationship between science self-efficacy and career aspirations in science. Those partial mediation effects contribute to increasing American students' future-oriented academic performances such as enjoying science and pursuing science careers. For Singaporean students, the full mediation effects of instrumental motivation on the link between science self-efficacy and career aspirations in science encouraged science educators to help students make future-oriented plans to enjoy learning science and pursuing science careers.

On the other hand, negative relation between instrumental motivation and science self-concept illustrates that American students have very stable and ground perception of science values in their daily lives and their science self-concept would not change by instrumental motivation (Bong & Skaalvik, 2003). Therefore, it is suitable for educators in America to understand that middle school students with instrumental motivation prefer mastery experiences and future-oriented performances in science domain rather than their science scores.

In sum, the present findings and previous research recommend that students' science achievements at schools, teachers' recognitions, and parents' supports in conjunction with self-efficacy bolster adolescents' competences and self-confidence to persistence in learning science as well as pursuing STEM careers (Hazari, Sonnert, Sadler, & Shanahan, 2010; Aschbacher, Li, & Roth, 2010). In addition, for adolescents, having more STEM subject choices at school is a necessary step on the path to achieve their career aspirations in STEM field (Cleaves, 2005; Simpkins, Davis-Kean, & Eccles, 2006).

**Strengths and Limitations**

In the present study, considering that all items were ordered-categorical, factor analysis was conducted by a polychoric correlation matrix with weighted least square mean variance

(WLSMV) estimation method. WLSMV estimation method may have avoided several drawbacks, such as the attenuation of the relations among categorical indicators, the generation of biased standard errors, parameter estimates, test statistics (Brown, 2006; Flora & Curran, 2004), and biased estimates of factor means (Lubke & Muthén, 2004).

There are two contributions to extend the knowledge about factorial validity analysis of science self-concept, science self-efficacy, and intrinsic value of science. The present study clarifies and confirms that science self-concept and science self efficacy are clearly distinct concepts with differential impact on student motivation, emotion, and study behavior. It is unique to find the different factor construct of adolescents' intrinsic values of science between America and Singapore and then to develop further research questions. All findings in this study would contribute to American educators to further understand why Singaporean adolescents perform well in science domain.

Since this study utilized TIMSS 2011 data collections from America and Singapore only, the findings may be limited to international schools that are similar to American and Singaporean schools. TIMSS 2011 data used in the present study were collected from eighth grade students who were administered the test in 2011. Therefore, the results may be only generalizable to eighth graders. The study may also be somewhat limited by the self-report measures.

As the clustering of TIMSS 2011 data may result in score dependence, a single level model may underestimate the sampling variance in complex samples, and inflate the Type I error rate (Kline, 2011). A multilevel approach to investigating latent variables is possible using the WLSMV estimator, and may be preferable to a single level of analysis. Some factors such as school effectiveness, parents' support, and subject choice may indirectly influence career aspirations on student level (Fraser & Kahle, 2007). TIMSS data is an accessible and large data but it increases the difficulty for researchers to control and select variables.

## Conclusion

This study preliminarily aids to clarify the direct and indirect effects of students' science self-efficacy and self-concept on career aspirations in science using structural equation modeling (SEM). The present study highlights that American adolescents' science self-efficacy was a significant predictor for their career aspirations in science. American grade 8 students' instrumental motivation in science partially and positively mediated the associations between students' science self-efficacy and career aspirations in science. On the other hand, Singaporean $8^{th}$ grade students' science self-concept significantly and directly predicted their career aspirations in science. Singaporean adolescents' instrumental motivation positively and fully influences the relationships between students' science self-concept and their career aspirations in science. However, American $8^{th}$ grade students' science self-concept was not significantly related to their career aspirations in science.

Since some factors such as school effectiveness, parental support, and subject choice may indirectly influence student career aspirations (Fraser & Kahle, 2007; Lavigne & Vallerand, 2010), further studies will involve conducting a multilevel SEM approach to estimate two stage sampling variance using TIMSS 2011 samples (Kline, 2011). In addition, basing on the raised question: "How do culture contexts influence the measurement of students' intrinsic value of science?" in the present study, a future study would focus on different item responses tests to discover the differential measurement for intrinsic value between America and Singapore. Furthermore, it is worthy to examine the measurement invariance across two nations, if researchers want to conduct a direct modeling comparison between the two countries.

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