Australian Journal of Educational & Developmental Psychology. Vol 14, 2014, pp. 186-201

Seeding Science Success: Psychometric Properties of Secondary Science Questionnaire on Students' Self-Concept, Motivation, and Aspirations

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ABSTRACT

Every sphere of life has been revolutionised by science. Thus, science understanding is an increasingly precious resource throughout the world. Despite the widely recognised need for better science education, the percentage of school students studying science is particularly low, and the numbers of students pursuing science continue to decline internationally. This study establishes a new measure to investigate students' science self-concepts, motivation, and aspirations. The instrument shows sound psychometric properties in investigating secondary students' science self-concepts in different disciplines of science. Though available data show that students' science self-concepts are domain specific, it could not be shown that motivation and aspirations are.

Key words: Science, Self-concepts, Motivation, Aspirations

INTRODUCTION

Science is integral to improving the quality of life for humankind. Thus, every sphere of life has been revolutionised by science. As the pace of scientific research output accelerates, the average citizen is faced increasingly with having to grapple with science matters in everyday life. A sound knowledge of science can only be an advantage. Even such routines tasks as grocery shopping are more informed by a basic understanding of science. But many citizens are not equipped to: personally assess the facts, separate the facts from opinion or from political spin, or science from non-science. Without such capacity, they are likely to be predominantly influenced by the prevailing messages delivered in popular media or within their own communities. Hence, the notion of science literacy as an important public goal needs to be addressed as a matter of urgency.

In relation to the importance of understanding science, Aschbacher, Roth, and Li (2010) state that understanding concepts and principles in science is a more and more valuable practice and experience throughout the world. Further, DeBoer (2000) states, "science classes should give students the knowledge and skills that are useful in the world of work and that will enhance their long term employment prospects in a world where science and technology play such a large role" (p. 592). According to Franklin (2013), "If you want significant facts, interesting facts, useful facts, believable facts, go to science" (p. 31). Clearly, knowledge and appreciation of science is a valuable asset to have.

In spite of the importance of science education throughout the world, the percentage of school students studying science is alarmingly low (Birrell, Edwards, Dobson, & Smith, 2005; Hannover & Kessels, 2004). There is an international decline in the number of students studying science, especially in developed countries such as the United States of America (U.S. Department of Education, 2006), the United Kingdom (Schoon, 2001), and Germany (Roeder & Gruehn, 1997). This has resulted in a lack of available expertise to fill science positions and thus endangers economic supremacy in a competitive and rapidly-changing world.

A similar situation has been experienced in Australia during the past three decades (Wood, 2004; Hassan, 2008). McDougall (2011) reports that the number of Year 12 students studying any of the science subjects has plummeted from 94% to just over 50% in the past 20 years. Further, Smith (2011) reports that while the decrease in science enrolments is slowing, there is no sign that the lowest point has been reached yet.

The problem of declining enrolments is recognised not only by government departments and researchers, but is increasingly being reported on in the popular media. For example, *The Sydney Morning Herald* (2011, December 22, p. 12) reported that when high school students were asked why they had not chosen biology, chemistry, or physics in their senior years, many replied that they found it hard to imagine themselves as scientists, presumably wearing a white coat and huddled over test tubes in a lab. This response reveals a wide misunderstanding about the role of science education and the work of scientists.

The consultancy practice, Access Economics, warns that Australia's innovation and productivity goals are at risk, due to an emerging shortage of research skills. Somewhat encouragingly, it argues that the answer might be found in our schools. While students say they are interested in science, almost 50% perceive science to be 'hard', 36% are bored, 25% dislike science lessons, and most know little about the range of science-related jobs on offer. Thus, much more needs to be done in Australia to make science education relevant, accessible, and enjoyable.

This burning issue of declining student enrolments in science must be addressed to ensure that science is advanced in this country. Preparing now can save us from 'repairing in the future'. Today's science students are tomorrow's inventors, medical researchers, engineers, teachers, and leaders.

Past research suggests that the decline in science enrolments is related to students' motivation, academic abilities, and teaching methods (Hassan & Treagust, 2003). However, a comprehensive study has not been conducted to identify key psychosocial drivers that influence the uptake of science (Chandrasena, Craven, Tracey, & Dillon, 2012a). This is unfortunate, as psychosocial constructs may serve as the drivers of desirable educational outcomes in science. For example, self-concept and motivation have been demonstrated by a body of international research to be key drivers in students' engagement of science (Chandrasena, Craven, Tracey, & Dillon, 2012b). Thus, the main objective of the present study was to capitalise on advances in self-concept, motivation, and aspirations theory and research in order to develop psychometrically sound measures of secondary students' science self-concepts, motivation, and aspirations.

METHOD

The research used a design comprising a quantitative study. Hence, a survey instrument was designed to collect data that could be analysed using advanced statistical procedures to address the overarching research aims. As analyses should be dictated "first and foremost by a strong theoretical base" (Hair et al., 2006, p. 714), survey items were developed on the basis of relevant theory and research. Consistent with the overarching aim of this research, survey items were carefully chosen that addressed domains of students' self-concept, motivation, and aspirations in different domains in science (biology, chemistry, earth and environmental science, and physics).

Participants

Students at the secondary level from three schools in New South Wales, Australia participated in this study. Three hundred and ninety five students from Year 7 to Year 12 (aged from 12 years to

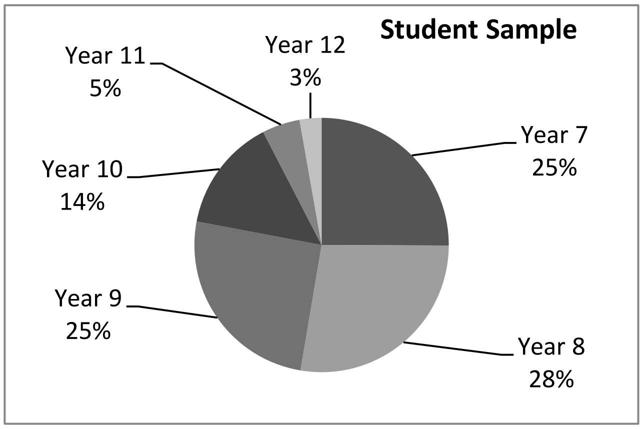

Figure 1: The distribution of the student sample

17 years) participated in the survey (females = 208, males = 187). The distribution of the student sample among the Years is presented in the Figure 1.

Recruiting Procedures

A convenience sampling technique was used in this study. Once ethical approvals were obtained from the relevant organisations and schools agreed to participate, information letters and consent forms including information on the project and participant confidentiality were sent to schools to be distributed to the parents/guardians of students in Years 7 - 12 for their consent for their children to participate. Students who returned their parental consent forms were invited to participate in a 30-40 minute survey. Consent was given on a voluntary basis. All participants were provided with an information letter which outlined all the details of the study.

A paper version of the survey was administrated in school halls and classrooms with minimal disturbance to normal school work and procedures. All participants were required to sign a consent form indicating that they had read and understood the

information letter, before commencing to participate. At the beginning of the survey it was announced to the students that the data collected would only be used by the researcher for research purposes without reporting back the raw data to the schools, parents, and other people. Students were also informed that the consent form they sign in the student questionnaire booklet (i.e., first page of the booklet) will be removed and stored separately after the survey in order to make students' answers confidential without giving others the chance to identify the individuals.

Instrumentation

A new measurement battery was constructed for the purpose of this study - The Science Secondary Questionnaire (SSQ). The SSQ comprises the following measurement scales: Science Self-Description Questionnaire (SSDQ), Science Motivation Questionnaire (SMQ), and Science Aspiration Questionnaire (SAQ). Each of the scales is measured on a six-point Likert scale (1= *strongly disagree* to 6= *strongly agree*). Survey items of the SSQ are shown in the Appendix and a brief description of each scale is as follows.

Science self-description questionnaire (SSDQ). The SSDQ is a researcher-devised multidimensional measure of students' science self-concepts based on Marsh's (1990) self-description questionnaire. This scale comprises survey items related to students' science self-concepts. Based on the findings of Marsh and Craven (2006), science self-concept was conceptualised as a multidimensional construct. To reflect the multidimensional nature of students' science self-concepts, this scale includes the following five subscales: biology, chemistry, earth and environmental science, physics, and general science.

Science motivation questionnaire (SMQ). The SMQ was adapted from a motivation scale developed by Marsh, Craven, Hinkley, and Debus (2003) to measure science motivation. The SMQ comprises three different motivational orientations: mastery, intrinsic, and ego in different domains in science.

Science aspirations questionnaire (SAQ). Educational aspirations and career aspirations are measured by a scale adapted from Yeung and McInerney's (2005) school motivation and aspirations scale.

Data Analysis

Survey data were initially entered in Microsoft Excel sheets from which datasets were prepared for use in SPSS and Mplus. Data screening and general analyses (reliabilities, frequencies, etc.) were performed using SPSS 20.0. Descriptive analyses were carried out on the data for students' science self-concepts, motivation, aspirations, and achievement, followed by reliability tests. The Confirmatory Factor Analysis (CFA) was performed using Mplus 6.12 and was done to examine the factor structure of the measurement subscales of the instrument.

Treatment of missing data. A multiple imputation frame work was used to treat missing values of the data set. In the multiple imputation method each missing value is replaced with a set of plausible values that represent the uncertainty about the right value to impute instead of filling in a single value for each missing value (Rubin, 1987).

Confirmatory factor analysis. Once adequate reliability estimates were demonstrated for each factor, a series of CFAs were conducted to validate the factor structure for each scale in the instrument using Mplus. Specifically, CFA was used to investigate the structural validity of the constructs of interest.

Invariance testing. The survey items should measure the same construct comparably across different subgroups of the sample (Brown, 2006). Such recognised equivalence, also referred to as *invariance* (Byrne, 2006), is a necessary prerequisite for establishing validity of the survey scales as well as generalisability. For this research, two different groupings were of interest: (a) age of the child, and (b) gender of the child.

RESULTS AND DISCUSSION

Psychometric Properties of SSDQ

Reliability. Table 1 shows reliability estimates for the SSDQ factors. The results of the reliability estimates for the five subscales of the SSDQ for the total sample show good measures, with alpha coefficients ranging between .89 and .90. Acceptable measures of reliability were obtained across the different subgroups (stage, gender) such as males and females, and stage 4 (Years 7 and 8), stage 5 (Years 9 and 10), and stage 6 (Years 11 and 12) students for the SSDQ (Aron & Aron, 2003), with alpha coefficients ranging from .68 to .91.

Structural validity. The statistics used to evaluate the factor structure include chi square statistics such as the value of chi square (χ^2), degrees of freedom (df), and probability (*p*). In addition, overall fit indices such as root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI) were used to evaluate the model fit. The chi square results for the SSDQ were $\chi^2 = 433.52$, df = 160, $p < .001$. A very low *p* value (less than .05) suggests a poor or unsatisfactory fit. However, since the chi square is overly sensitive to sample size, there is a need for consideration of other more stable model fit indices (Byrne, 2006). Thus, the overall model fit indices are acceptable according to the criteria

Table 1: Reliability Estimates (Cronbach's Alpha) for the Total Sample and Subgroups for the Science Self-Description Questionnaire (SSDQ)

Grouping categories	Science	Biology	Chemistry	Earth & Environmental Science	Physics
Total	.90	.90	.89	.90	.90
Male/Female	.81/.90	.87/.91	.88/.90	.78/.87	.88/.85
Stage 4/5/6	.89/.86/.82	.89/.87/.90	.90/.89/.88	.90/.89/.68	.91/.91/.77

suggested by Marsh, Balla, and Hau (1996), where a CFI and TLI greater than .9 and an RMSEA less than .08 are considered acceptable. Results for the SSDQ were: CFI = .918, TLI = .903, and RMSEA = .066 with a 90% confidence interval of 0.059–0.074, indicating a good fit.

In evaluating the psychometric properties of the scales, it is also worthwhile and important to examine the factor loadings of the respective items and the factor correlations for a complete assessment of the factor structure, to ensure items adequately represent the factor structure. Tables 2 and 3 indicate the factor loadings and factor correlations respectively. Table 2 illustrates that every item loading is statistically significant and with the exception of one loading, substantial in size (ranging from .46 to .86). While one factor loading was below the base level of acceptability of .5 suggested by Hair et al. (2006), Hills (2008) suggests that a factor loading as low as .3 may be acceptable, so this item was retained. Table 3 shows that factor correlations between general science and the four disciplines of science range from 0.48 to 0.76, indicating that the factors, while correlated, are distinguishable.

Table 2: Standardised Factor Loadings for the Science Self-Description Questionnaire

Items	GS	BG	CH	EE	PH
1	.82	.79	.76	.77	.71
2	.65	.46	.60	.50	.66
3	.75	.85	.80	.86	.86
4	.73	.84	.86	.85	.86

* All factor loadings are significant at $p < .05$

Note: All parameter estimates are presented in completely standardized format. Of the SSDQ self-concept factors, GS = General Science, BG = Biology, CH = Chemistry, EE = Earth & Environmental Science, PH = Physics.

The model fit statistics show a good fit. Thus, the five factor model of SSDQ (Figure 2) is accepted and findings provide strong support for the structural validity of the SSDQ.

***Factorial invariance of SSDQ for gender*.** Results for invariance of gender are presented in Table 4. The invariance is evaluated by the application of two multi-group CFA models (M1 and M2). The goodness of fit indices of both of the models were acceptable. The change in CFI values of the two models was used to evaluate the invariance. A change in CFI of less than +/- .01 is supportive of invariance (Cheung & Rensvold, 2002). The change in CFI between M1 and M2 is less than .01 (i.e., 0.002). Hence, the minimal level of invariance is achieved (Cheung & Rensvold, 2002).

Table 3: Factor Correlations of the Science Self-Description Questionnaire

	GS	BG	CH	EE	PH
GS	1.00				
BG	.72	1.00			
CH	.76	.68	1.00		
EE	.62	.59	.59	1.00	
PH	.53	.48	.60	.53	1.00

* All correlations are significant at $p < .05$

Note: All parameter estimates are presented in completely standardized format. Of the SSDQ self-concept factors, GS = General Science, BG = Biology, CH = Chemistry, EE = Earth & Environmental Science, PH = Physics.

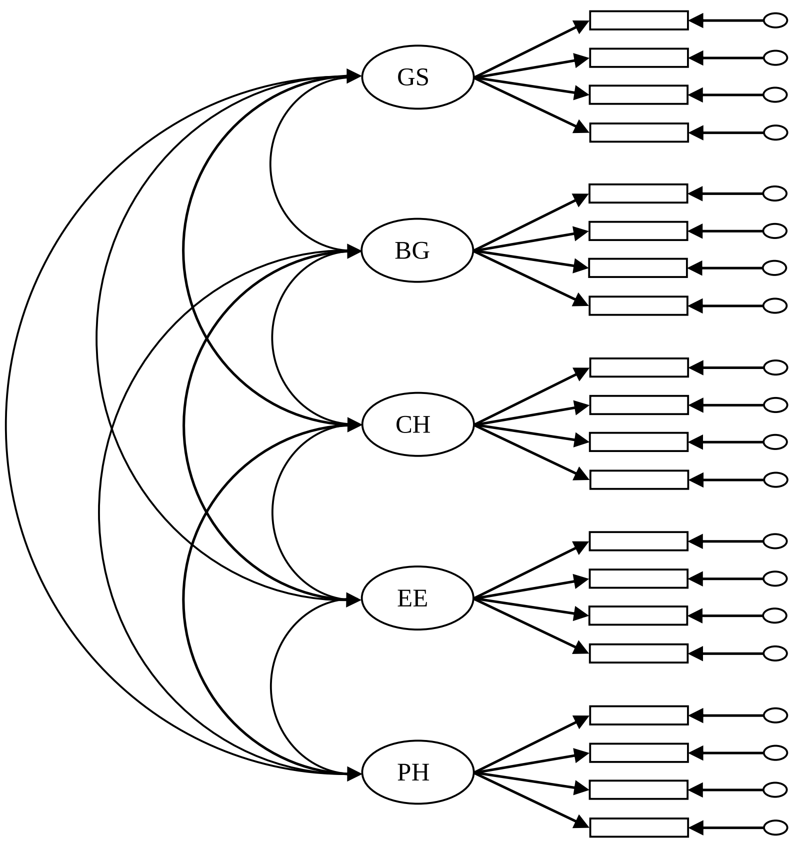

Figure 2: Factorial structure of the SSDQ

Note: *GS = General Science, BG = Biology, CH = Chemistry, EE = Earth & Environmental Science, PH = Physics.*

Table 4: Summary of Goodness of Fit Statistics for Invariance Testing for the Science Self-Description Questionnaire (SSDQ) Across Gender

Model	Model Description	χ^2	*df*	CFI	TLI	RMSEA	90% CI for RMSEA
M 1	Completely free	599.93	320	.912	.895	.068	.059—.076
M 2	FL, IT = Invariant	623.80	340	.910	.900	.070	.058—.074

Note: χ^2 = Chi Square, *df* = degrees of freedom, CFI = Comparative Fit Index, TLI = Tucker-Lewis Fit Index, RMSEA = Root Mean Square Error of Approximation, FL = Factor Loadings, IT = Intercepts.

Factorial invariance of SSDQ for secondary school stage. Results for invariance of secondary schooling stages: i.e., early (Years 7 & 8 = Stage 4), middle (Years 9 & 10 = Stage 5), late (Years 11 & 12 = Stage 6) are presented in Table 5. Similar to invariance testing for gender, the invariance for school stage is evaluated by the application of two multi-group CFA models (M1 and M2). The goodness of fit indices, indicate an acceptable fit for the two models proposed. The observed change in CFI between M1 and M2 was less than .01 (i.e., 0.006). Thus, according to the criteria suggested by Cheung and Rensvold (2002) the desirable minimal level of invariance is achieved for stage of secondary school.

Table 5: Summary of Goodness of Fit Statistics for Invariance Testing for the Science Self-Description Questionnaire (SSDQ) Across Secondary Schooling Stages

Model	Model Description	χ^2	*df*	CFI	TLI	RMSEA	90% CI for RMSEA
M 1	Completely free	720.58	480	.923	.908	.062	.053—.072
M 2	FL, IT = Invariant	777.64	520	.917	.909	.062	.053—.071

Note: χ^2 = Chi Square, df = degrees of freedom, CFI = Comparative Fit Index, TLI = Tucker-Lewis Fit Index, RMSEA = Root Mean Square Error of Approximation, FL = Factor Loadings, IT = Intercepts.

Psychometric Properties of SMQ

Reliability. Table 6 shows reliability estimates for the SMQ factors. The results of the reliability estimates for the three SMQ factors show acceptably reliable measures, with Cronbach‘s Alpha coefficients in the range of .89 to .90 for the total sample. Acceptable measures of reliability were also obtained across the different subgroups of the SMQ (Aron & Aron, 2003), with alpha coefficients ranging from .80 to .94. Thus, the SMQ demonstrates reliable measures for the total sample, as well as for the specific subgroups of interest (i.e., stage, gender).

Table 6: Reliability Estimates (Cronbach's Alpha) for the Total Sample and Subgroups for the Science Motivation Questionnaire (SMQ)

Grouping categories	Mastery	Intrinsic	Ego
Total	.90	.90	.89
Male/Female	.84/.77	.92/.91	.94/.94
Stage 4/5/6	.87/.85/.80	.91/.93/.90	.94/.94/.94

The chi square statistics in the model fit results for SMQ were $\chi^2 = 154.62$, df = 51, $p < .001$. Though the p value was very low (less than .05) importantly, the overall model fit indices were acceptable (Marsh et al., 1996), with CFI = .958, TLI = .946, and RMSEA = .072, with a 90% confidence interval of 0.060–0.086.

Structural validity. Factor loadings and factor correlations are shown in Tables 7 and 8 respectively. Table 7 shows that every item loading in SMQ is statistically significant and substantial in size (ranging between .63 and .92).

Table 7: Standardised Factor Loadings for the Science Motivation Questionnaire

Items	Mastery	Intrinsic	Ego
1	.63	.83	.92
2	.76	.84	.80
3	.80	.81	.85
4	.73	.85	.91

* All factor loadings are significant at $p < .05$

Table 8 shows that the factor correlations ranged from 0.35 to 0.64 and are therefore distinguishable.

Table 8: Factor Correlations of the Science Motivation Questionnaire

	Mastery	Intrinsic	Ego
Mastery	1		
Intrinsic	.64	1	
Ego	.40	.35	1

* All correlations are significant at $p < .05$

According to the above results, a substantial degree of variance in the items is accounted for by the factor loadings of the respective factors. The model fit statistics also show a good fit. Thus, the three factor model of SMQ (Figure 3) is accepted.

***Factorial invariance of SMQ for gender*.** Results for invariance of gender are given in Table 9. The proposed models show acceptable model fit statistics for a good fit. Based on the evaluation of two multi-group CFA models (M1 and M2), the change in CFI value of the two models was .01. Hence, a desirable minimal level of invariance was achieved (Cheung & Rensvold, 2002).

Table 9: Summary of Goodness of Fit Statistics for Invariance Testing of the Science Motivation Questionnaire (SMQ) Across Gender

Model	Model Description	χ^2	*df*	CFI	TLI	RMSEA	90% CI for RMSEA
M 1	Completely free	212.61	102	.956	.943	.075	.061—.090
M 2	FL, IT = Invariant	249.68	114	.946	.938	.079	.066—.092

Note: χ^2 = Chi Square, *df* = degrees of freedom, CFI = Comparative Fit Index, TLI = Tucker-Lewis Fit Index, RMSEA = Root Mean Square Error of Approximation, FL = Factor Loadings, IT = Intercepts

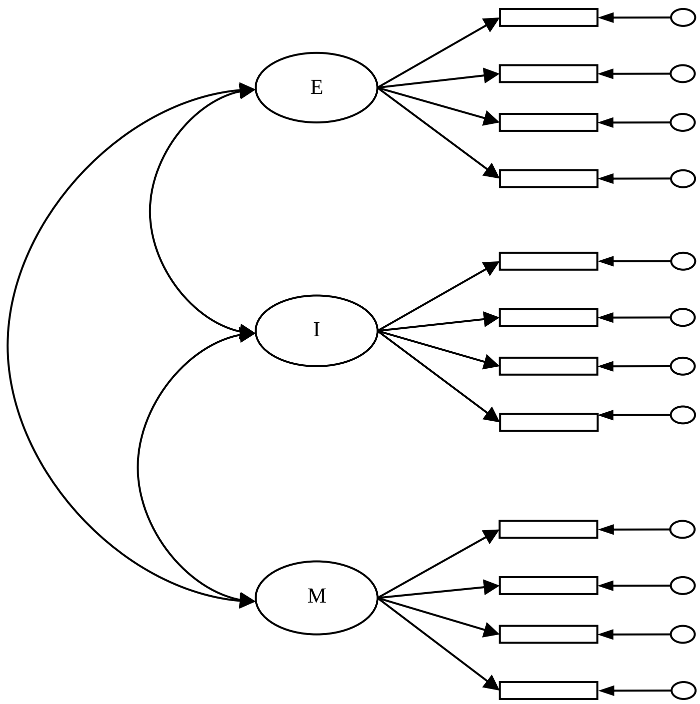

Figure 3: Factorial structure of the SMQ
Note: E = Ego, I = Intrinsic, M = Mastery

Factorial invariance of SMQ for secondary school stage. Results for invariance for secondary schooling stages are given in Table 10. The proposed two models demonstrated acceptable goodness of fit indices. Two multi-group CFA models (M1 and M2) show that the change in CFI value of the two models is less than .01 (i.e., 0.001). Thus, a desirable minimal level of invariance is achieved (Cheung & Rensvold, 2002).

Table 10: Summary of Goodness of Fit Statistics for Invariance Testing for the Science Motivation Questionnaire (SMQ) Across Secondary Schooling Stages

Model	Model Description	χ^2	*df*	CFI	TLI	RMSEA	90% CI for RMSEA
M 1	Completely free	250.58	153	.955	.941	.070	.054—.086
M 2	FL, IT = Invariant	276.26	177	.954	.948	.066	.050—.081

Note: χ^2 = Chi Square, *df* = degrees of freedom, CFI = Comparative Fit Index, TLI = Tucker-Lewis Fit Index, RMSEA = Root Mean Square Error of Approximation, FL = Factor Loadings, IT = Intercepts.

Psychometric Properties of SAQ

Reliability. Table 11 shows reliability estimates for the SAQ factors. Acceptable reliability measures were achieved for both factors of the SAQ with Cronbach's Alpha coefficients of .90.

Table 11: Reliability Estimates (Cronbach's Alpha) for the Total Sample and Subgroups for the Science Aspiration Questionnaire (SAQ)

Grouping categories	Science Aspirations	Career Aspirations
Total	.90	.90
Male/Female	.89/.90	.94/.95
Stage 4/5/6	.90/.90/.89	.92/.95/.97

Acceptable measures of reliability were also obtained across the different subgroups of the SAQ (Aron & Aron, 2003), with alpha coefficients ranging from .89 to .97. Thus, the subscales of the SAQ demonstrate reliability measures for the total sample, as well as for the specific subgroups of interest (i.e., stage, gender).

Structural validity. The chi square statistics in the model fit results for SAQ were $\chi^2 = 64.13$, df = 23, $p < .001$. As with the previous scales, the p value is very low (less than .05) suggesting a poor or unsatisfactory fit. However, the overall model fit indices are acceptable (Marsh, et al., 1996), with CFI = .983, TLI = .974, and RMSEA = .068, with a 90% confidence interval of 0.049–0.088.

Factor loadings and factor correlations are shown in Tables 12 and 13 respectively. Table 12 shows that every item loading in SAQ is statistically significant and substantial in size (ranging between .76 and .94).

As seen in Table 13, the correlation between factors is very high, being .94. Such a high correlation suggests that each factor is measuring very similar constructs. While such highly correlated factors can be problematic, given that they are outcome variables, as opposed to predictor variables, each was included in evaluating relations using SEM (Structural Equation modeling) path analysis.

According to the above results a substantial degree of variance in the items is accounted for by the factor loadings of the respective factors. The model fit statistics also show a good fit. Hence, the two factor model of SAQ (Figure 4) is accepted.

Table 12: Standardised Factor Loadings for the Science Aspiration Questionnaire

Items	SA	CA
1	.76	.93
2	.89	.88
3	.88	.94
4	.78	-

* All factor loadings are significant at $p < .05$

Note: All parameter estimates are presented in completely standardized format. SA = Science Educational Aspirations, CA = Career Aspirations.

Table 13: Factor Correlations of the Science Aspiration Questionnaire with Teacher and Student Ratings

	SA	CA
SA	1	
CA	.94	1

* All correlations are significant at $p < .05$
Note: All parameter estimates are presented in completely standardized format. SA = Science Educational Aspirations, CA = Career Aspirations.

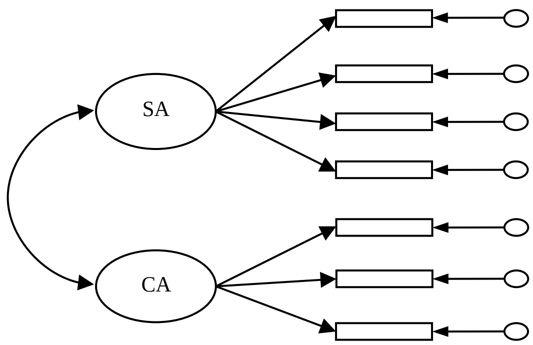

Figure 4: Factorial structure of outcome variables

Note: SA=Science Aspirations, CA=Career Aspirations

Factorial invariance of SAQ for gender. Results for invariance for gender are given in Table 14. The goodness of fit indices demonstrate an acceptable model fit for both of the proposed models. Based on the evaluation of two multi-group CFA models (M1 and M2), the change in CFI value of the two models was less than .01 (i.e., 0.001). Hence, a desirable minimal level of invariance is achieved (Cheung & Rensvold, 2002).

Table 14: Summary of Goodness of Fit Statistics for Invariance Testing for the Science Aspiration Questionnaire (SAQ) Across Gender

Model	Model Description	χ^2	*df*	CFI	TLI	RMSEA	90% CI for RMSEA
M 1	Completely free	94.63	46	.981	.970	.074	.053—.096
M 2	FL, IT = Invariant	98.96	53	.982	.975	.067	.046—.088

Note: χ^2 = Chi Square, *df* = degrees of freedom, CFI = Comparative Fit Index, TLI = Tucker-Lewis Fit Index, RMSEA = Root Mean Square Error of Approximation, FL = Factor Loadings, IT = Intercepts.

Factorial invariance of SAQ for secondary school stage. Results for invariance for secondary schooling stages are given in Table 15. The proposed models demonstrate a good fit. Two multi-group CFA models (M1 and M2) show that there is no change in the CFI value of the two models. Thus, a desirable minimal level of invariance is achieved (Cheung & Rensvold, 2002).

Table 15: Summary of Goodness of Fit Statistics for Invariance Testing for the Science Aspiration Questionnaire (SAQ) Across Secondary Schooling Stages

Model	Model Description	χ^2	*df*	CFI	TLI	RMSEA	90% CI for RMSEA
M 1	Completely free	137.33	69	.974	.959	.088	.066–.109
M 2	FL, IT = Invariant	151.32	83	.974	.966	.080	.059–.100

Note: χ^2 = Chi Square, df = degrees of freedom, CFI = Comparative Fit Index, TLI = Tucker-Lewis Fit Index, RMSEA = Root Mean Square Error of Approximation, FL = Factor Loadings, IT = Intercepts.

Factorial Integrity of the SSQ Instrument

Factorial integrity is maintained when all of the measurement scales (i.e., SSDQ, SMQ, and SAQ) are combined into one assessment battery (Figure 5). Specifically, factorial integrity is maintained in that items load only on to those factors they are intended to load on to; that is, no cross-loadings emerge.

The chi square statistics in the model fit results for the assessment battery were $\chi^2 = 1526.18$, df = 731, $p < .001$. As the p value is very low (less than .05) the results suggest a poor or unsatisfactory fit. However, the overall model fit indices are acceptable (Marsh, et al., 1996) with CFI = .914, TLI = .903, and RMSEA = .053 with a 90% confidence interval of 0.049–0.057.

CONCLUSION

All scales of the SSQ had excellent internal consistency reliability, substantial item-to-factor loading, and moderate correlations between factors demonstrating that factors were measuring distinct factors, all of which provides good support for the structural validity of SSQ's scales. Further, adequate levels of invariance were demonstrated across the grouping variables of interest (i.e., gender and secondary schooling stages). In addition, the overall instrument demonstrated acceptable model fit in CFA when all of the measurement scales (i.e., SSDQ, SMQ, and SAQ) are combined into one assessment battery.

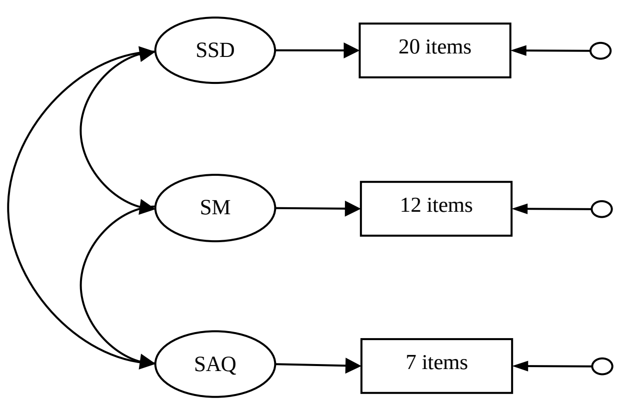

Figure 5: Factorial structure of the science assessment battery

Note: SSDQ = Science Self-Description Questionnaire, SMQ = Science Motivation Questionnaire, SAQ = Science Aspiration Questionnaire.

When conducting the CFAs, the SSDQ demonstrates acceptable overall model fit for Science, Biology, Chemistry, Earth and Environmental Science, and Physics. Both the SMQ and SAQ demonstrated acceptable overall model fit only for Science but not at the level of the different disciplines of Science, namely Biology, Chemistry, Earth and Environmental Science, and Physics. This indicates that while students' science self-concepts are domain specific, available evidence suggests that Science Motivation and Science Aspirations are not.

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APPENDIX

BREAKDOWN OF MEASURES

Statements of the student questionnaire on Self-Concept: adapted from SDQII

	SCIENCE
1	I am good at **SCIENCE**
2	I do badly in tests of **SCIENCE**
3	I have always done well in **SCIENCE**
4	**SCIENCE** is one of my best subjects

	BIOLOGY
5	**BIOLOGY** is one of my best subject areas
6	I often need help in the subject area **BIOLOGY**
7	I am good at **BIOLOGY**
8	I have always done well in **BIOLOGY**

	CHEMISTRY
9	**CHEMISTRY** is one of my best subject areas
10	I do badly in tests of **CHEMISTRY**
11	I am good at **CHEMISTRY**
12	I have always done well in **CHEMISTRY**

	EARTH & ENVIRONMENTAL SCIENCE
13	**EARTH & ENVIRONMENTAL SCIENCE** is one of my best subject areas
14	I have trouble understanding anything with **EARTH & ENVIRONMENTAL SCIENCE** in it
15	I am good at **EARTH & ENVIRONMENTAL SCIENCE**
16	I have always done well in **EARTH & ENVIRONMENTAL SCIENCE**

	PHYSICS
17	**PHYSICS** is one of my best subject areas
18	I look forward to **PHYSICS** classes
19	I enjoy studying for **PHYSICS**
20	I never want to take another **PHYSICS** course

Statements of the Questionnaire on Student Motivation (Marsh et al, 2003)

(Mastery, Intrinsic and Ego orientations)

	SCIENCE MOTIVATION
1	I feel most successful in **SCIENCE** when I reach personal goals
2	I feel most successful in **SCIENCE** when I really improve
3	I feel most successful in **SCIENCE** when I work to the best of my ability
4	I feel most successful in **SCIENCE** when I do something I could not do before
5	I do **SCIENCE** because I like learning new things
6	I do **SCIENCE** because I enjoy thinking hard
7	I do **SCIENCE** because I like to solve hard problems
8	I do **SCIENCE** because I enjoy trying to understand new things
9	I feel most successful in **SCIENCE** when I do better than other students
10	I feel most successful in **SCIENCE** when I show other students that I am the best
11	I feel most successful in **SCIENCE** when I do something others cannot do
12	I feel most successful in **SCIENCE** when I know more than other students

Statements of the Questionnaire on Student Aspirations (Yeung and McInerney, 2005)

(Educational and Career aspirations)

	SCIENCE EDUCATIONAL ASPIRATIONS
1	I hope I continue my **SCIENCE** studies
2	I want to go on to college or university education to study **SCIENCE**
3	I try my best hoping to get into an advanced educational institution to study **SCIENCE**
4	I am eager to do some advanced courses in **SCIENCE**

	CAREER ASPIRATIONS
1	I wish to get a good job in **SCIENCE**
2	I very much hope to get a good paying **SCIENCE** job when I am employed
3	I hope I will find desirable employment in the future in **SCIENCE**