Factors Influencing Students' Intentions to Study Science in Upper Secondary

Sallimah M. Salleh
Universiti Brunei Darussalam

Abstract

This paper investigated the factors that influenced lower secondary students' intentions to study science in upper secondary. It goes on to determine how a theoretical model, The Theory of Planned Behavior could explain how these factors would affect their intentions in taking up sciences as the major subjects in upper secondary. Through the understanding of these factors, a thorough curriculum provision, improved pedagogies and relevant initiatives may be created to encourage students to take up science in upper secondary. A total of 1,726 students (aged between twelve to sixteen years old) randomly selected from nine secondary schools, responded to the survey questionnaire, the instrument used for the study. The data collected was analyzed using factor analysis and structural equation modeling. The key findings are: students' intentions to study science in upper secondary is influenced by their attitude towards science (their enjoyment, and feeling comfortable when learning science); the subjective norms (parents and family members); and perceived behavioural control (viz. their ability and capability to learn science successfully). The Structural Equation Modeling (SEM) of the personal, social and control factors of the Theory of Planned Behaviour, that was used to analyse the influence of attitude towards science, subjective norms, perceived behavioural control, and social support on students' intention to take up science in upper secondary, indicated a fair model that predicts 38% of variance in intention and 24% variance in behaviour.

1. Introduction

The present study was conducted as a result of the realization that the number of students studying science subjects at the upper secondary school level was in decline. If allowed to continue, this trend will impede future developments in the science and technology sectors, which in turn will have dire consequences on the vision of the government to provide quality education towards a developed, peaceful and prosperous nation, through the acquisition of excellent and adequate human resources that would compete in a global economy where science and technology predominate.

Therefore, the purpose of this study was to investigate the factors that influence students' uptake of science in upper secondary. The following research questions guided the study: (1) What are the respective factors of students' attitudes towards science, subjective norms, and perceived behavioural control that influence their intentions to take up science in upper secondary? (2) How do the students' attitudes towards science, subjective norms and perceived control factors predict students' intentions to take up science in upper secondary? (3) Is the TPB model suitable in predicting intentions to study science in upper secondary?

2. Theory of Planned Behaviour

The purpose of this study was to use a theoretical model that could predict and explain students' intentions to take up science in upper secondary schools by focusing on psychosocial factors. To serve this purpose, a widely applied psychosocial theory, the theory of planned behaviour (TPB) (Ajzen, 1991) was examined and adapted. It is a model that employs psychosocial factors to predict and explain behavior in specific contexts (Ajzen, 1992, p. 191). It is capable of identifying the beliefs linked to implementation behavior (Haney, Czerniak, & Lumpe, 1996) and the operationalization of the research constructs is easy and simple (Sutton, 1998).

According to the TPB (see Figure 1), three direct factors are required to predict behaviour (B) and behavioural intention (I). The first factor is *attitude towards the behaviour* (AB), which is a personal factor that refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the particular behavior, in the current study, the degree to which a student has a favourable or unfavourable evaluation of science learning.

The second factor is *subjective norm* (SN), which is a social factor that refers to the perceived social pressure to perform, or to not perform, the behavior, in this study, the perceived social pressure to study or not to study science in upper secondary.

The third factor is the degree of *perceived behavioural control* (PBC), which refers to the perceived ease or difficulty of performing the behavior, in this study, the perceived ease or difficulty to study science in upper secondary.

The current study adapted the TPB as the theoretical model that would be used to predict and explain students' perceptions about the factors that influence them to take up science in upper secondary. Based on this theory, this study proposed that there might be a positive relationship between *intention* (I) to take up science and *attitude towards science* (AB), *subjective norms* (SN) and *perceived behavioural control* (PBC).

The TPB is considered an appropriate theoretical framework for the current study because of its unique approach to examining behaviour and its wide applicability in behavioural studies.

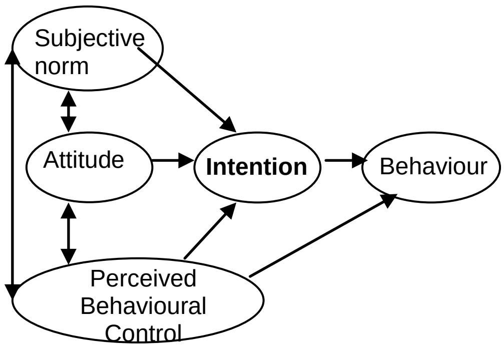

Figure 1. Theory of planned behavior (Ajzen, 1991)

The current study also theorised that both direct and indirect paths between perceived behavioural control and behaviour were predicted in the students' learning science in upper secondary if students perceive they have control in their learning of science in upper secondary and their intention to learn science is high.

In order to verify these assumptions, the following research propositions and hypotheses have been stipulated based on the requirements of TPB which prescribes the demonstration of predictive relationships of the TPB constructs and the verification of hypotheses linking beliefs to behaviour [1]. The hypotheses have been derived from the respective propositions based on the TPB. Derivation of hypotheses from a theory base should "lead logically to the hypothesis as a solution to the problems and makes it clear why it should be tested" [15].

3. Research Propositions and Hypotheses

The research propositions theorized the relationships among the factors that would predict use either directly or indirectly. The propositions are adapted from Ajzen's TPB. The propositions provided a theoretical framework from which research hypotheses were drawn. The theoretical propositions were expressed in the form of causal, not correlational, relationships supported by empirical findings of cumulated TPB findings.

Proposition 1: Student taking science in upper secondary is predicted by their intention to study science and by perceived behavioural control. Proposition 1 is tested by two research hypotheses:

Hypothesis H1: There will be a positive relationship between students' studying science in upper secondary (B) and the *intention* to study science (I).

Hypothesis H2: There will be a positive relationship between students' studying science in upper secondary (B) and *perceived behavioural control* (PBC).

Proposition 2: Students' intention to study science in upper secondary is predicted by their attitude towards science, subjective norms, and perceived behavioural control. Proposition 2 is tested by the following three research hypotheses:

Hypothesis H3: There will be a positive relationship between students' *intention* to study science in upper secondary and *attitude towards science.*

Hypothesis H4: There will be a positive relationship between students' *intention* to study science in upper secondary and *subjective norms.*

Hypothesis H5: There will be a positive relationship between students' *intention* to study science in upper secondary and *perceived behavioural control*.

Proposition 3. The personal, social, and control factors of TPB model (attitudes toward science, subjective norms, and perceived behavioural control) can explain significantly students taking science in upper secondary. The accompanying hypothesis is:

Hypothesis H6: The TPB model of personal, social, and control factors (*students' attitude towards science, subjective norms,* and *perceived behavioural control*) provides a significant model fit in predicting students studying science in upper secondary.

Results of the tests of hypotheses H1 to H6 would provide statistical support for assessing the personal, social, and control factors that influence students' studying science in upper secondary, and ultimately achieve the purpose of the current study that is, to examine the personal, social, and control factors that influence students to take up science in upper secondary.

4. The Study

This study employed a survey research method that has been frequently used in research in the field of education. A survey research method is particularly useful for generating quantitative data that can be used to establish the basis for wider generalization. A questionnaire (see Table 1) was administered to obtain participants' responses to the variables under investigation. The questionnaire administered in the current study was used to test the statistical relationships among the constructs of the Theory of Planned Behaviour that underpins this research study: *attitude towards science* (AB), *subjective norms* (SN), *perceived behavioural control* (PBC), *intention* (I) and *Study science* (B).

Table 1. Variables and items of the questionnaire

Variable	Questionnaire Item
Feeling about learning science (AB)	ab1. I like learning science. ab2. I feel that learning science is important. ab3. I feel anxious when I learn science. ab4. I enjoy learning science. ab5. I feel comfortable learning science. ab6. I feel hopeless when I learn science.
Who influence you to learn science? (SN)	sn1. My parents sn2. My family (siblings, cousins, uncles, aunts, grandparents) sn3. Principal sn4. Teachers sn5. Friends
Factors that assist me to study science (PBC)	pbc1. I am certainly able to study science if I want to. pbc2. I am entirely capable of learning science successfully. pbc3. I have the resources, the knowledge, and the skills to learn science effectively. pbc4. Teachers help me to learn science. pbc5. I can learn science if I have support from friends. pbc6. I can learn science if I have support from my parents. pbc7. I can learn science if I have interesting teaching and learning resources.
Intention I study science in future (I)	i1. I will take up science subjects in upper secondary. i2. I will learn science to get a job. i3. I will learn science to gain more scientific knowledge. i4. I will learn science if I get a good grade in science examination.
Frequency of Learning science (B)	How often did you learn science on your own this week? How often did you learn science on your own in the last six months? How often did you learn science on your own last year?

A structured questionnaire was used as the research instrument in the current study. Because the research constructs of this study (that is, attitudes and perceptions) are latent variables which are not directly observable, the use of multiple item scales is beneficial since it ensures greater variability and enhances reliability of measures because the errors of each item tend to cancel each other out (DeVellis, 1991).

The questionnaire was developed using information derived from focus group discussions with a sample of Year 10 students. A pre-designed structured protocol was used to initiate the focus group discussion. The items of the protocol were tailored for measures of perceptions (AB, SN, PBC, I and B), obtained from the latent variables which were adopted and modified from various previous published studies.

A total of nine schools were chosen for the study. A total number of 1,726 students (aged between twelve and sixteen years old) responded to the survey questionnaire. The sample size (N = 1,726) for the study adequately supported the use of structural equation modeling, the analytic technique employed in this study. Table 2 shows the demographics of the students respondents.

Table 2. Demographics of Student Respondents (N=1726)

Variable	Group	Valid N	n	Valid %
Sex	Boys	1692	1000	59.1
	Girls		692	40.9
Age (years)	12	1720	8	0.5
	13		211	12.3
	14		732	42.6
	15		432	24.6
	16+		346	20.1
School	A	1726	119	6.9
	B		147	8.5
	C		329	19.0
	D		130	7.5
	E		273	15.8
	F		224	13.0
	G		154	8.9
	H		115	6.7
	I		233	13.5

5. Statistical Analyses and Findings

Structural Equation Modelling (SEM) is the main statistical analysis approach employed in this study. SEM is a comprehensive statistical approach to testing hypotheses about relations among observed and latent variables [10]. Specifically, SEM examines a set of relationships between one or more observed independent variables, either continuous or discrete, and one or more dependent variables, either continuous or discrete. Both of which can either be factors or measured variables [20] by combining factor analysis and path analysis [12].

Exploratory factor analysis (EFA) was employed to ascertain that the factor structure of the observed variables was the same as that in the proposed measurement model, and that the proposed latent variable-observed variable relations were supported empirically. The EFA was administered on the whole sample.

Maximum likelihood (ML) extraction method was used with Promax rotation, a method of oblique rotation that allows for correlation among variables. Oblique rotation was chosen as some correlations were expected among the variables. A factor loading of .3 was used as a lower cut-off value as recommended for exploratory analysis [14]. The results of the EFA show that 55.2 % of total variance was accounted for in this factor solution. Table 5.1 presents the factor loadings.

Table 5.1 shows most of the items were loaded on their hypothesized factors (based *a priori* on the five constructs of the TPB: *attitude toward behavior* (AB), *subjective norms* (SN), *perceived behavioural control* (PBC), *intention* (I) and *use of ICT* (B). All the items (Items ab1 to u4) show factor loading above the lower cutoff value of .3.

The general structural equation model, also known as a full model consists of two parts: a *measurement model* and a *structural model* [11]. The measurement model is made up of observed variables (or indicator variables), *viz.* the questionnaire items, linking to latent variables (the five constructs of TPB) via a confirmatory factor model. The measurement model is also known as a confirmatory factor analytic model.

The structural model is made up of latent variables linking to each other via systems of simultaneous equations, with arrows specifying the direction of hypothesized causal paths. As such, a structural model is analogous to a path diagram, and structural modeling is likened to path analysis (see Figure 2).

This two-stage model assessment [2] is useful in avoiding confounding interpretation due to interactions between measurement and structural models [17]. Items with low levels of reliability or multiple factor loadings may lead to misinterpretation of model misfit as the source of misfit could originate from within-construct (measurement model) or between-construct (structural model) estimation.

The reliability and validity of the items in the questionnaires were analyzed simultaneously with SEM. The validity and reliability of each observed variable in the measurement model were assessed.

Validity of an observed variable refers to the extent to which it measures what it is supposed to measure, that is, the latent variable. Validity of observed variables in SEM, is assessed by the magnitude of standardized regression weights estimates, λ [4]. Items with estimates of .7 or higher were considered to show sufficient validity [18]. Test results are presented in the third column in Table 3.

Table 3. Exploratory Factor Analysis (EFA) with 25 observed variables for 5 Latent Variables (i.e. the 5 TPB constructs)

Item	Rotated Component					
	1	2	3	4	5	6
ab1	.639		.329			
ab2			.385			
ab3	.729					
ab4	.685					
ab5	.666					
ab6	.651					
sn1				.803		
sn2				.748		
sn3				.752		
sn4			.480	.471		
sn5						.506
pbc1			.649			
pbc2			.720			
pbc3			.488			
pbc4			.609			
pbc5						.827
pbc6						.673
pbc7		.398				.502
i1		.666				
i2		.766				

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i3	.652	
i4	.684	
u2		.696
u3		.803
u4		.796

Table 3 shows the final observable variables that were valid and reliable in measuring the respective latent variables.

Item reliability refers to the consistency of measurement among a set of observed variables. In SEM, reliability is assessed by the magnitude of the square multiple correlations, SMC (R^2) between the items and the constructs [4]. Items with R^2 of above .5 indicates sufficient reliability (Bagozzi& Yi, 1988). Items that show SMC above the cut-off value of .5 indicate more than 50% of the variance is explained by the item and that the measurement error in the item is less than 50% of the variance. Test results are presented in the fourth column in Table 4.

Using AMOS statistical program, the full structural model is specified, and estimated. The criteria for the structural model assessment includes the criteria employed for the measurement model assessment as shown in Table 5 as well as two other criteria: path significance or standardised regression estimates (*B*) and squared multiple correlations (R^2).

Table 4. Validity and Reliability of Observable Variables

Latent Variable	Observed variable	Validity (λ)	Item reliability (R^2)
Attitude towards Behaviour (AB)	ab1	.76	.57
	ab4	.82	.68
	ab5	.70	.49
Subjective norms (SN)	sn1	.89	.80
	sn2	.70	.47
Perceived Behavioural Control (PBC)	pbc1	.73	.53
	pbc2	.72	.52
Intentions (I)	i1	.70	.42
	i2	.71	.46
	i3	.71	.46
Take-up Science Behaviour (B)	u2	.62	.39
	u3	.81	.66
	u4	.66	.44

The path significance indicated by the standardized regression estimate assesses the effect of one variable on another variable. The significance level was set at .05. AMOS is capable of assessing direct, indirect and total effects of variables in hierarchical causal relationships among variables in the research model. Standardised regression estimates are also measures of the validity of indicator variables of each construct.

The R^2 are used to assess the amount of variation in a latent variable that is explained by the predictor variables. For a well specified model such that the latent variable is associated strongly with its predictors and is measured adequately by the observed variables, the R^2 is expected to be high. The R^2 is also used as a measure of reliability of each of the indicator variables.

The final assessment of the research model was made by examining all the criteria of fit. Table 5 shows the evaluation criteria of overall structural equation models.

The fit indices were used as the criteria for measurement model and the subsequent full structural model assessment. The values of the model fit indices were adopted from Bagozzi and Yi [3] and Hair, Anderson, Tatham and Black [8]. In this study, a combination of all fit indices was used to assess a model.

The path significance indicated by the standardized regression estimate assesses the effect of one variable on another. The significance level was set at .05. The R^2 are used to assess the amount of variation in a latent variable that is explained by the predictor variables. For a well specified model such that the latent variable is associated strongly with its predictors and is measured adequately by the observed variables, the R^2 is expected to be high. The R^2 is also used as a measure of reliability of each of the indicator variables.

Table 5. Criteria for Model Fit Assessment, Item Reliability and Validity

Fit	Characteristics	Recommended values for acceptable fit
Chi-square (χ^2)	$H_0: \sum = \sum(\theta)$ $H_A: \sum = \sum_\alpha$	Small chi-square ($p > .05$)
Root Mean Square Error of Approximation (RMSEA)	Average discrepancy per df expected to occur in the population.	Lower than .08
Item assessment for reliability and validity:		
Squared Multiple Correlation (R^2)	Used as a measure of reliability of each indicator variable Used to assess the amount of variation in latent variables explained by predictors	$R^2 > .50$
Standardised Regression Estimates	Used as a measure of validity of each indicator variables (λ) Path significance indicating the effect of one variable on another variable (β)	$\lambda > .70$

5.1. What factors of students' attitudes towards science, subjective norms and perceived control factors influence their intention to study science in upper secondary?

The first research question was to identify the factors of students' attitudes towards science, subjective norms and perceived control factors that influence their intentions to take up science in upper secondary. Figure 2 and Table 6 shows that the attitudinal factors that validly and reliably influence students' intention to study science in upper secondary are *liking science* (ab1), *enjoy learning science* (ab4), and *comfortable learning science* (ab5). The factors of subjective norms that validly and reliably influence students' intention to study science in upper secondary are their *parents* (sn1) and *family members* (sn2). The perceived control factors are measured validly and reliably by their *ability to learn science* (pbc1) and *capability to learn science successfully* (pbc2).

5.2. Predicting students' intentions to take up science in upper secondary

The second research question was: how do the students' attitudes towards science, subjective norms, and perceived control factors predict students' intentions to take up science in upper secondary?

In order to answer this research question, the two research propositions and the associated research hypotheses (H1, H2, H3, H4, and H5) were formulated to provide statistical assessments of the propositions that were required for answering the question (see section 3).

The first research proposition states that students taking science in upper secondary is predicted by their intention to study science and by perceived behavioural control factors.

Figure 2 shows that coefficients for the paths from *intention* to *behaviour* (B = .56, $p < .001$) is positive and significant. This test result supported hypothesis, HI that states that there will be a positive and significant relationship between students' studying science in upper secondary (B) and the intention to study science (I). But the path from *perceived behavioural control* to *behavior* (B = .01, p = .823) is positive but not significant. This test result does not support hypothesis, H2 that postulated a positive and significant relationship between students' studying science in upper secondary (B) and *perceived behavioural control* (PBC).

Proposition 2 states that students' intention to study science in upper secondary is predicted by their attitude towards science, subjective norms and perceived behavioural control. Figure 5.1 also shows that that the coefficients for the paths from *attitude towards learning science* to *intention* (B = .50, $p < .001$); from *subjective norms* to *intention* (B = .14, $p < .001$); and from *perceived behavioural control* to *intention* (B = .43, $p < .001$) are all positive and significant at their respective p levels. These test results show support for hypotheses H3, H4 and H5 (see section 3) that postulates *intention* is predicted by the three latent variables; *attitude towards learning science, subjective norms,* and *perceived behavioural control*.

5.3. Is the TPB model suitable in predicting intentions to study science in upper secondary?

The third research question was: is the TPB model suitable in predicting students' intentions to study science in upper secondary?

The third research proposition states that the personal, social, and control factors of TPB model (*attitudes towards science, subjective norms, and perceived behavioural control)* can predict significantly students' taking science in upper secondary. Table 5.4 shows the fit statistics (chi-square and RMSEA) provide statistical support for Hypothesis 6 i.e. the TPB model of personal, social, and control factors (*students' attitude towards science*, *subjective norms*, and *perceived behavioural control*) provides a significant model fit in predicting students studying science in upper secondary. From Figure 5.1, the strength of the predicting power of *subjective norms* (B = .14) is the weakest when compared with the other two predictor variables, *attitude towards learning science* (B = .50) and *perceived behavioural control* (B = .43). The predicting power of *intention* (B = .56) to *behaviour* (taking science in upper secondary) is stronger than the predicting power of *perceived behavioural control* (B = .01) to *behaviour*.

In conclusion, the Structural Equation Model (SEM) that was used to analyse the influence of attitude towards science, subjective norms, perceived control factors on students' intention to take up science in upper secondary, indicated that the TPB is a fair model that predicted 38% of variance in intention and 24% variance in behavior (taking science in upper secondary).

From the SEM model, it is shown that the students' behavior of learning science (as measured by the frequency of learning science on their own this week, last six months and last year) is mostly influenced by their learning of science in the previous month (R^2=.81, SMC = .66).

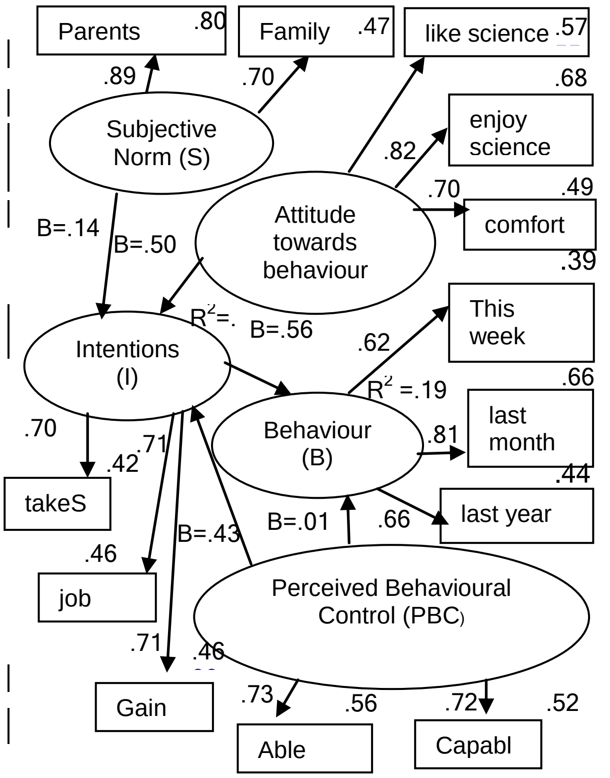

Figure 2. SEM for five latent variables in TPB

Table 6. Results of Criteria for Model Fit Assessment, Squared Multiple Correlations

	Fit Indices	Fit Statistics	Recommended Fit Criteria
	Chi-square (χ^2)	1513 p=.000	p<.05
	Degrees of freedom (df)	270	
Over-all Model Fit	Normed χ^2	5.6	Between 1.0 and 3.0
	RMSEA	.07	Lower than .08
		Intention	Behaviour
R^2	Explained variance in Dependent Variables (R^2)	38%	24%

6. Discussions and conclusions

The major findings of the current research are that students' intentions to study science in upper secondary level are influenced to a greater extent by their attitude towards science, and perceived behavioural control; but at a lesser extent by the subjective norms. However, their behavior in studying science can be predicted mostly by their intentions.

Students' attitudes towards science are validly and reliably linked to their liking, enjoying and feeling of comfort when learning science. The subjective norms that validly and reliably influence students' intention to study science in upper secondary level are their parents and family members. Finally, the perceived behavioural control factors are measured validly and reliably by their capability and ability to learn science successfully.

The significant finding of the current study that show evidence for the weak influencing effect of subjective norms, comprising of parents and peers, on students' intention; is in contrast to the importance of classroom environment and peers, and home environment and parents, on students' attitudes [7]. However, students' perceptions of peers' and parents' unenthusiastic attitudes towards a science subject such physics may contribute towards their decisions to pursue science education at tertiary level or not [13]. Nevertheless, the system of channeling students into streams such as express or normal, after their examinations results, may be a factor that needs to be addressed in future research.

The current study also provides further support of the applicability of the Theory of Planned behavior as psychosocial theoretical model in explaining and predicting behaviours in the field of education [5]. The use of structural equation modeling as a statistical and analytical tool has also been reported in other studies that apply the Theory of Planned Behaviour [16]. However, the use of Rasch analysis may also be useful to overcome the psychometric limitations inherent to Likert scale type of data such as used in this study.

7. Implications and recommendations

Teachers should employ teaching strategies that would evoke students' enjoyment, and provide a comfortable environment for learning science. One strategy that may provide the enjoyment and comfort is to use Information and Communication Technology in the teaching of science. The use of ICT tools such as PowerPoint, simulations, and Internet resources would make learning science enjoyable.

The school should encourage the participation of parents and family members in their initiatives to motivate and encourage students to study science. One way to involve parents besides the current practice of disseminating assessment reports is to involve parents in career and guidance counseling. Both students and parents must be made aware of the career opportunities that would be available with a good science qualification.

Student support groups should be organized. Support groups can be led by outstanding students who can encourage weaker students to study science effectively and to coach their peers in their learning. The participation of these students in the support groups should be given due acknowledgment and credits. Peer influence is important in developing an individual's motivation, and sense of ability and capability in performing well in science.

In order to instill the appropriate attitudes among students, schools should organize more visits to work places to expose students to the real working environment. Prominent members of the society should be invited to share their experiences and promote the importance of science education in their careers. Shadowing or interviewing prominent members of society could also be given as an assignment for students to do during the school holidays. Observations of professionals in their respective fields may exert subtle impact on students' decision to pursue science education at tertiary level.

8. References

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