Factors Influencing Undergraduate Students' Motivation to Study Science

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Abstract
The purpose of this exploratory study was to assess the relative importance of a number of variables in predicting students' motivation to study science. The study employed achievement goal theory to investigate students' motivation in science. Questionnaire data were collected from 571 undergraduate students, comprising both males and females enrolled in undergraduate science degrees at two mid-sized public universities in Australia. Factor analysis and descriptive statistics were used to analyse the data. Results indicate that motivated students were predominantly mastery goal orientated. The research sheds light on the theoretical framework of achievement motivation that goes beyond mastery and performance-approach goals. Educational implications of the study are discussed.

Introduction and Framing
A major goal of science education is the attainment of scientific literacy, which includes deeper conceptual understanding of key scientific principles and ideas, the ability to apply scientific knowledge in real life contexts, as well as the ability to identify problems and conduct scientific inquiry [1]. Understanding motivation is critical for reforming school curriculum, increasing learning, and improving career aspirations of students [2]. Historically studied as a general trait, motivation is now studied multi-dimensionally, through personal goal orientations (students' reasons for engaging in specific academic tasks), and self-efficacy (belief in one's ability to succeed in a particular situation) constructs [3]. This study is based on the belief that students' motivation in science and aspirations for a career in science are developed as a result of cognitive and affective motivational components that influence "the arousal, direction and sustainment of students' science-learning behavior" [4, p.1051]. The study examines students' motivation to study science through the lens of achievement goal theory by assessing the relationships between attitudinal and motivational factors.

As initially researched, achievement goal theory stipulates that an individual could have two goal orientations or purposes for pursuing competence-based actions: learning or a performance orientation [5, 6, 7, and 8]. Individuals with a learning orientation towards a certain task or goal seek to increase their competence and skills by learning or mastering the new situation. In contrast, individuals with a performance orientation towards a certain task or goal strive to demonstrate competence by proving their ability in order to gain favourable judgments by others or by avoiding unfavourable judgments of their ability. Elliot and McGregor [9] have bifurcated the learning goal orientation into mastery-approach and mastery-avoidance (the 2X2 goal orientation model) in order to explain why a learning approach can sometimes lead to less positive outcomes than the proving orientation. The research on this model is in its early stages, however, and the mastery-avoidant orientation has also been theorized to be less prevalent than the other three orientations and only relevant in certain situations [10]. Therefore, for the purposes of this review and study, the trichotomous goal orientation model was our focus.

The purpose of this study is to assess factors that influence students' motivation to study science. The study provides an integrated model of students' motivation by combining affective and cognitive factors, with the aim of providing a comprehensive explanation of students' achievement goal orientations in science.

Methodology

Participants and data Collection

The participants were 571 primarily first year undergraduate university students enrolled in general science courses at two mid-sized Australian universities. The universities were chosen because of convenience and permission to conduct the study. The sample for this study contained 299 males (52.3%) and 272 females (47.6%). The majority (95%) of the participants were in their first year of introductory science courses. Only 5% of the participants were enrolled in advanced stage of science courses. Students were selected because of the importance of the transition from high school to university education and because students in this age group have more educational alternatives than they have experienced previously at school.

The data for this study was collected at the end of the semester in the middle of the academic year through the administration of a questionnaire (Students' Motivation in Science Questionnaire - SMSQ) developed by the first researcher. Participants took approximately 15 minutes to complete the questionnaire.

Results and Discussion

Preliminary Analyses

The Statistical Program for the Social Sciences, SPSS version 21.0 was used to compute descriptive statistics, mean comparisons, and correlations among the model variables. Confirmatory factor analyses (CFA) were conducted on the items to examine the factorial validity and to guide scale construction. When using FCA, the chi-square statistics assesses absolute fit of the model but it is sensitive to sample size.

Internal consistency reliability, discriminant validity, and predictive validity were used as the criteria to ensure the validity and reliability of the instrument. Negatively worded items were reverse scored. Mean scores for the total questionnaire was computed for each student. Descriptive statistics (range, mean, standard deviation, and Cronbach alpha coefficients) were carried out on the sample. In support of reliability and validity of the scales of SMSQ, the scales were found to correlate with the scales upon which they were largely based. Enjoyment for science (r=.64), Mastery goal (r=.85), Performance-approach goal r=.89), Performance-avoidance goal (r=.81), Self-concept in science (r=.82), Teacher support (r=.79), Teacher enthusiasm (r=.81), Career interest in science (r=.65), Academic interest (r=.56), and Student engagement (r= .67). These results of the relevant constructs identified for inclusion in the questionnaire supported the findings of the factor analysis showing the ten factors.

An exploratory factor analysis was first conducted on 51 items of the SMSQ. The Kaiser–Meyer–Olkin Measure (KMO) of Sampling Adequacy was 0.92 for the exploratory factor analysis. Kaiser [11] characterizes KMO measures in the 0.90s as "marvellous". Results that are 0.60 or greater indicate that researchers can comfortably proceed with the factor analysis. The analysis confirmed the ten-scale structure of the SMSQ with 55 items. All items have a loading of at least 0.40 on their a priori scale and on no other scale.

Using the individual as the unit of analysis, the mean correlations of scales with all other scales attested to the discriminant validity of the SMSQ. The mean correlations ranged from 0.18 to 0.42. These data suggest that the SMSQ assesses distinct but somewhat overlapping aspects of students' interest in and motivation for studying science. Overall, the reliability estimates, confirmatory factor analysis, and mean correlation measures all indicate that the scales of the SMSQ are valid measures.

The results of independent-samples t-tests indicated that there was a significant difference between the men (M=104.96, SD=15.75) and women (M=98.94, SD=12.33) in their motivation ratings t (123) =−2.028, p=.05. The data for all students were combined for analyses. Descriptive statistics were calculated for all the variables in the study. Means and standard deviations for all scales for the total samples are presented in Table 1.

Table 1 Descriptive Statistics of the SMSQ Scales used in this Study

Scale	Mean	SD	No. of Items
Enjoyment of Science	2.28	.75	6
Mastery Goal	3.14	.95	5
Performance-approach Goal	3.33	.64	5
Performance-avoidance Goal	2.23	.77	4
Self-concept	2.03	.73	7
Teacher Support	3.44	.67	4
Teacher Enthusiasm	2.79	.70	5
Career Interest in Science	2.90	.72	5
Academic Interest	3.11	.74	8
Student Engagement	2.67	.71	4

Correlation Analysis

Pearson product-moment correlation coefficients were calculated for all pairs of variables on the full sample. Table 2 presents the simple correlations between the scales. As predicted, there are positive correlations between the scales.

The most positive correlations are obtained between adjacent concepts (scales) (e.g., student engagement and mastery goal), while concepts at the opposite end of the continuum (i.e., avoidance-approach goal and self-concept of ability) show the most negative correlations. Correlations involving other concepts are progressively more positive as on moves from one end of the list of the scales to the other suggesting that self-determination of a continuum [12] underlies the ten subscales and therefore supports the validity of the instrument.

Table 2 Zero-order Correlation Coefficients between the Scales

Scales	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. ENJ	.10									
2. MAS	.56**	.10								
3. PER	.21**	.17**	.10							
4. AVO	.24**	.37**	.37**	.10						
5. SCS	.32**	.44**	.32**	.29**	.10					
6. TES	.31**	.50**	.44*	.57**	.45**	.10				
7. TEE	−.09**	−.18**	−.34**	.41**	−.20**	−.24**	.10			
8. CIS	.30**	.12**	.20**	−.09**	.42**	.30**	.16**	.10		
9. INT	.42**	.48**	.57**	−.29**	.18**	.26**	.31**	.28**	.10	
10. ENG	.30**	.30**	.45**	−.44**	.19**	.37**	.40**	.37**	.26**	1.0

Skewness	.08	.79	-.04	.95	-.45	-.04	.52	.08	-.76	.08
Kurtosis	-.31	.78	.67	.77	1.20	.61	.43	.71	.80	-.60
Cronbach's α	.64	.85	.89	.81	.82	.79	.81	.65	.56	.67

Note. ENJ = Enjoyment for science, MAS = Mastery goal, PER = Performance-approach goal, AVO = Performance-avoidance goal, SCS = Self-concept in science, TES = Teacher support, TEE = Teacher enthusiasm, CIS = Career interest in science, INT = Academic interest, ENG = Student engagement, * $p<.05$, ** $p< .01$.

Most people, but students in particular, feel more competent, more in control, more motivated, and perform better when they are able to express their preferences and make choice [13]. The majority of the participants in this study have chosen to study science, but others were required to enrol in science as a prerequisite for science-related course.

It is possible that students with high levels of interest and engagement in science will most likely pursue their science study. It is possible that students who have a strong belief of success in science will most likely select science and pursue a successful science career. By contrast, students who lack interest in science will avoid science if they can.

The findings indicate that positive attitudes towards science and academic interest are two stronger predictors. Equally important is that learning through interest enhances personal and professional growth, conceptual understanding, and personal satisfaction [14]. The study supports other earlier research on achievement motivation that has shown that students who do well in science tend to find science interesting, challenging their abilities and is relevant to their career prospects [15]. Achievement and motivation play an important role in students' choice of career and the choice of study subject directly connected to it.

Thus, students must sustain high motivation and positive self-concepts to achieve their goals in science. The promise of long-term rewards is a critical aspect of students' motivation. Therefore, these finding should not surprise science teachers and science educators.

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