

Cognitive Correlates of Different Academic Subjects in School Setting

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Abstract

This is an empirical study which examined the relevance of intelligence tests (verbal and non-verbal) in different academic subjects. A sample of 200 students (100 males and 100 females) of Eleventh class from different schools of Shimla district in Himachal Pradesh (India) were tested on Standard Progressive Matrices (SPM) and General Mental Ability Test (GMAT) together with their scores on different subjects. A multiple regression analysis revealed an interesting pattern of relationship. SPM has been found to be the best correlate of Mathematics and Science subjects contributing 53% and 58% of variance in males' sample and 32% and 36% of variance in females' sample. Whereas, GMAT, correlated best with languages and social science subjects accounting for 28% to 44% in males' sample and 28% to 56% in females' sample.

Keywords: SPM, GMAT, Academic subjects

1. Introduction

Academic achievement has been a topic of considerable interest and research for a very long time. One of the most important concerns of education is to ensure that each child is able to make most of his abilities. Achievement in itself has become more or less powerful symbol and way of life. However, even if the course of life is not determined by achievement, it is essentially directed by it. Academic achievement is the outcome of the training imparted to a student by the teacher in the school situation. Academic achievement is defined as the mean achievement score in the examination of each subject i.e., curriculum of the students taught by the teacher (Mehta and Kumar, 1985; Naderi, et. al., 2009). Countless number of studies have been undertaken which either focused exclusively on academic achievement or investigated academic achievement in relation to other cognitive, social and personal factors. Most of these studies have sought to determine factors that enhance academic achievement. The implications of these relationship for education are apparent since achievement in skill, concepts and content are the acknowledge goals of the education process (Palaniappan, 2005).

Academic achievement is a complex performance. However, the determiners of the level of achievement in school courses are not yet definitely pinpointed. But, there is enough evidence to show that academic achievement is not unidimensional phenomena, but a multidimensional activity. Oates (1929), Eysenck (1960), Vernon (1961) and Mohan & Kumar (1975) suggest that intelligence, personality, learning method and motivational variables are responsible for total academic performance. There have been considerable number of scientific investigations in the area of academic achievement in order to find out its stable determiners.

Some attempts have been fructified in establishing the direct relationship between certain variables while some are still under investigation. There are different (vast) correlates of academic achievement viz. personality, intelligence, study habits, locus of control, achievement motivation, adjustment, creativity, attitude, field dependence-independence etc. But, the best correlate of academic achievement is intelligence which is a well established fact (Sinha, 1970; Dhaliwal & Sharma, 1994; Sharma, 2008). Whatsoever, there are various other researches where the correlation between intelligence and academic achievement have been found to be low, insignificant and even low negative (Bhatnagar, 1969; Contractor, 1972; Lunge, 1974; Malik, 1977; Lewis & Todd, 1978; Mehta & Kumar, 1985 and Kumari & Rao, 2000). Some studies failed to give clear cut results. Actually, there are gaps in knowledge. The scores have been used in a composite manner which clouds the picture as even intelligence is subjected to qualitative differences in terms of different subjects and kinds of intelligence tests. The historical perspective of intelligence tests, revealed that Spearman's 'g' factor had a more dominating role in test construction. But as pointed out by Anastasi (1968) in the past few decades (Vernon, 1960 & Humphreys, 1962) have witnessed more leanings towards the "vast multiplicity of behaviour elements which may become organized into clusters either hereditary or experimental linkages". Vernon (1960) has even broken up "g" factor into two major group factors viz. a) Verbal-educational (V:Ed.) and b) Practical: Mechanical (K:M). Verbal educational tests are more likely to tap languages and social sciences and practical mechanical tests to predict the science and arithmetic reasoning (Vernon, 1960).

Thus, one single intelligence test does not reflect the overall achievement and that is why the variance in academic achievement cannot be explained purposefully. This requires to be put to test (Sharma, 2008). In reality, intelligence tests indicate less well what pupils will do in art, drawing, science, mathematics and writing. Investigators have found correlations that differ a little but on the average, the correlation between mental tests and abilities in these subjects is only about .20 and in one study intelligence has explained only 14% -15% of variance in academic achievement (Mehta & Kumar, 1985). The *r* value is quite low and on this basis, a teacher can hardly predict whether a bright child will write, draw, do art work or do mathematical solutions better than average or a dull child. From the content it is to be expected that the abilities measured by intelligence tests have less in common with the abilities needed in these skill subjects because generally and mostly, the intelligence tests are verbal in nature and these skill subjects call for more non-verbal abilities.

The best way to predict one's worth is through verbal educational tests (V: Ed.) and practical-Mechanical tests (K: M) which will tap different kinds of abilities of an individual. Intelligence will be able to explain more variance when two tests are taken. Hence, the educational tasks have to be sliced up. So, the present study is centered on it i.e. two different types of intelligence tests viz. SPM (Non-verbal, K:M) and GMAT (Verbal, V:Ed) have been used to predict "the optimal level of academic achievement in different educational subjects separately". The present study is highly important on two counts:

First, intelligence is verbal as well as non-verbal and the researches need to know whether verbal intelligence is a better predictor of academic achievement or nonverbal intelligence.

Secondly, most of the early researches on the relationship between intelligence and academic achievement, considered total academic achievement as the criterion measure which provides only the clouded and distorted picture. So, in the present study, instead of taking a composite score, academic achievement in all the subjects have been taken separately. On the basis of above discussion it is expected that:

H_1 SPM would correlate best with nonverbal subjects viz., mathematics and science subjects.

H_2 GMAT would correlate better with verbal subjects such as English, Hindi, Sanskrit (Languages) and social science subjects.

Hence, in the present study, a regression analysis was computed to find out the best set of predictors in different subjects on males and females samples separately.

2. Methods and Materials

2.1 Design

Initially, a co-relational design was used to find out the pattern of relationship between academic achievement and intelligence tests. The study was conducted on 200 subjects comprising of equal number of males and females of eleventh class from different schools of Shimla district of Himachal Pradesh, India. Further, multiple regression analysis was computed separately for males and females sample to find out the exact variance shown by different intelligence tests in different academic subjects. Multiple regression allows us to identify a set of predictor variables which together provide a useful estimate of a participants likely score on a criterion variable.

2.2 Measures

1) *SPM (Standard Progressive Matrices, Raven, 1960)* was used to measure the nonverbal intelligence. It consists of 60 progressively difficult items divided into 5 sets of 12 and is not time bound. The rest-retest reliability on the Indian sample is .87 & the validity ranges between .85 to .95. (Kumar, 1974).

2) *GMAT (General Mental Ability Test, Jalota, 1973)* was used to measure verbal intelligence. It consists of 100 questions and is time bound. Reliability of the test is .94 and validity of the test is .78.

3) *Academic Achievement*: The marks secured by the students in different subjects in the 10th standard annual examination were used as the measure of academic achievement.

3. Results

The individual scores on SPM, GMAT and academic achievement in different subjects were subjected to correlational and multiple regression analysis separately for males and females and are presented in Multiple Regression Analysis in Table I and Table II respectively.

4. Discussion

As hypothesized in the former section, the results have revealed that SPM has turned out to be the better correlate of mathematics and science subjects in both the samples. In Males' sample, SPM has accounted for 58% of variance in Mathematics ($r = .71$; $\beta = .67$ and R^2 change = .58) and 53% of variance in Science subject ($r = .69$, $\beta = .63$ and R^2 change = .53) and in Females' sample, SPM has contributed 36% of variance in Mathematics ($r = .59$; $\beta = .57$ and R^2 change = .36) and 32% of variance in science subject ($r = .51$; $\beta = .49$ and R^2 change = .32) respectively. Thus, the hypothesis number one (H_1) stands accepted.

Whereas, GMAT has shown 9% of variance each in Mathematics and Science subjects in Males' sample ($r = .54$, $\beta = .38$ and R^2 change = .09 in Mathematics and $r = .41$, $\beta = .27$ and R^2 change = .09 in Science) and in Females' sample GMAT has predicted 8% to 13% of variance in Science and Mathematics ($r = .39$; $\beta = .24$ and R^2 change = .13 in Mathematics and $r = .34$; $\beta = .21$ and R^2 change = .08 in Science).

On the other hand, GMAT has emerged as the best predictor of languages and Social Science subjects in both the samples. In Males' sample, GMAT has explained 37% of variance in English ($r = .58$, $\beta = .51$ and R^2 change = .37); 32% of variance in Hindi ($r = .52$, $\beta = .41$ and R^2 change = .32); 28% of variance in Sanskrit ($r = .50$, $\beta = .48$ and R^2 change = .28) and 44% of variance in Social Science ($r = .63$, $\beta = .61$ and R^2 change = .44) and in Females' sample, GMAT has explained 45% of variance in English ($r = .62$, $\beta = .61$ and R^2 change = .45); 44% of variance in Hindi ($r = .61$, $\beta = .59$ and R^2 change = .44); 28% of variance in Sanskrit ($r = .50$; $\beta = .48$ and R^2 change = .28) and 56% of variance in Social Science ($r = .65$; $\beta = .63$ and R^2 change = .56). Hence, the hypotheses number two (H_2) stands proved and has been rationalized. Whereas, SPM has explained 6% of variance to the maximum of 11% in languages and Social Science subjects in Males' sample with 6% of variance in Social Science ($r = .33$, $\beta = .17$, R^2 change = .06); 8% of variance in Hindi ($r = .35$, $\beta = .18$ and R^2 change = .08); 9% of variance in Sanskrit ($r = .39$, $\beta = .11$ and R^2 change = .09) and 11% of variance in English ($r = .40$; $\beta = .24$ and R^2 change = .11) and in Females' sample, SPM has accounted for 6% of variance to the maximum of 13% of variance in languages and Social Sciences subjects with 6% of variance in Hindi ($r = .31$; $\beta = .18$ and R^2 change = .06); 8% of variance in Sanskrit ($r = .09$; $\beta = .03$ and R^2 change = .08); 10% of variance in English ($r = .37$; $\beta = .28$ and R^2 change = .10) and 13% of variance in Social Science ($r = .28$; $\beta = .11$ and R^2 change = .13).

The rest of the variance could be explained by probably other social-psychological and attitudinal factors (Palaniappan, 2007a, 2007b; Horst, Finney & Barn, 2007; Laidra, et. al; 2007; Lipscomb, 2007). This very much makes the fact clear that no test can measure all aspects of intelligence. Different tests tap different abilities i.e., SPM (Non-Verbal educational test) is more likely to tap Mathematics and Science Subjects because these subjects are practical and mechanical (K: M) in nature and measure fluid (Gf) intelligence (Vernon, 1960). Thus, maximum variance is accounted for by fluid intelligence (SPM) in non-verbal subjects which call for the ability to solve new problems particularly when mentally effortful reasoning processes such as inference, induction, abstraction or synthesis are required.

This is the reason why mathematics and science subjects are strongly correlated with each other as both the subjects demand almost the same kind of specific abilities viz., mechanical and arithmetic reasoning associated with fluid intelligence (Sharma, 2008 and Kytala & Lehto, 2008). Whereas, GMAT apart from Gf is also a good measure of crystallized intelligence (GC) and is highly loaded with verbal material as it is verbal educational (V: Ed) in nature and hence shows the maximum correlation with language and social sciences as these subjects call for more verbal abilities viz., analogies, comprehension, language writing, spelling, grammar, sentence construction and cultural relevant knowledge and skills associated with concrete and crystallized

intelligence (Mohan & Kumar, 1975; Mehta & Kumar, 1985 and Sharma, 2008). Thus, the verbal subjects have strong bond with each other as they all entail the same kind of specific concrete and verbal abilities (Rohde & Thompson, 2007).

Though the results have also revealed the positive and significant correlations of these two tests with almost all the academic subjects but the r values are comparatively moderate (See Table I & II) as compared to their related respective subjects. This becomes obvious by looking at the r values which ranges from .56** to 58** in both the sexes which is due to the “g” factor i.e. the commonality of general intelligence, but the r values are far from perfect as both the tests tap different and specific abilities i.e., SPM taps abstract aspect of intelligence and is more oriented towards Mathematics and Science subjects, whereas, GMAT taps concrete and verbal aspect of intelligence and hence is more oriented towards languages and Social Sciences (Vernon, 1960; Cattell, 1971; Mohan & Kumar, 1975; Mehta & Kumar, 1985 ; Kyttala & Lohoto, 2008).

Thus, academic achievement is an important component of fluid (Gf) and crystallized (Gc) intelligence theory. According to this theory, the investment of fluid abilities into crystallized abilities occurs extensively during the schooling years, times when individuals acquire the complex abilities needed to learn school activities such as reading, writing and arithmetic (Vernon, 1960; Horn & Cattell, 1966; Sharma, 2008; Naderi et al., 2009).

The findings of the present study clearly reveal as to why sometimes the correlations are low or not significant between the two as one test is not a good measure of achievement and composite scores in achievement further clouds the picture. The present results somehow have cleared the dust regarding the relationship between the two.

5. Conclusion

To conclude, the contentions of Vernon (1960) were put to test partially by Mohan and Kumar, (1975) but, in the practical setting of achievement, it has seldom been the subject of enquiry. And the present results indicate that academic achievement in different subjects could be tapped only by different types of intelligence tests.

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Table 1. Results of the stepwise multiple regression analysis of cognitive correlates on academic subjects in males' sample (N = 100)

Academic Subjects (Dependent / Criterion Variables)	Cognitive Correlates (Independent / Predictor Variables)	r	β	R ²	R ² Change	F Change	Sig.
Mathematics	SPM	.71	.67	.58	.58	83.51	.01
	GMAT	.54	.38	.67	.09	5.71	.01
Science	SPM	.69	.63	.53	.53	70.56	.01
	GMAT	.41	.27	.62	.09	10.30	.01
English	GMAT	.58	.51	.37	.37	67.89	.01
	SPM	.40	.24	.48	.11	7.45	.01
Hindi	GMAT	.52	.41	.32	.32	61.46	.01
	SPM	.35	.18	.40	.08	7.18	.01
Sanskrit	GMAT	.50	.48	.28	.28	46.95	.01
	SPM	.39	.11	.37	.09	7.56	.01
Social Science	GMAT	.63	.61	.44	.44	49.70	.01
	SPM	.33	.17	.50	.06	8.53	.01

Note: In Males' sample, the r value between SPM and GMAT is 0.56, $p < .01$

SPM: Standard Progressive Matrices, GMAT: General Mental Ability Test

Table 2. Results of the stepwise multiple regression analysis of cognitive correlates on academic subjects in females sample (N = 100)

Academic Subjects (Dependent / Criterion Variables)	Cognitive Correlates (Independent / Predictor Variables)	r	β	R ²	R ² Change	F Change	Sig.
Mathematics	SPM	.59	.57	.36	.36	61.78	.01
	GMAT	.39	.24	.49	.13	10.30	.01
Science	SPM	.51	.49	.32	.32	50.84	.01
	GMAT	.34	.21	.40	.08	7.24	.01
English	GMAT	.62	.61	.45	.45	64.17	.01
	SPM	.37	.28	.66	.10	8.00	.01
Hindi	GMAT	.61	.59	.44	.44	55.05	.01
	SPM	.31	.18	.50	.06	7.18	.01
Sanskrit	GMAT	.50	.48	.28	.28	45.69	.01
	SPM	.09	.03	.36	.08	4.71	.05
Social Science	GMAT	.65	.63	.56	.56	72.77	.01
	SPM	.28	.11	.69	.13	4.28	.01

Note: In Females' sample the r value between SPM and GMAT is .58 $p < .01$

SPM: Standard Progressive Matrices, GMAT: General Mental Ability Test

Explanation of the symbols in the results section (Table 1 and 2)

Terminology: To understand the results, we need to clarify the certain terms expressed in symbols which are as follows:

$r = r$ is a measure of the correlation between the observed value and the predicted value of the criterion variable.

β = is referred to as beta value, which is a measure of how strongly each predictor variable influences the criterion variable.

R² = is the square of R and indicates the proportion of the variance in the criterion variables.

R² change = gives the exact variance of a predictor variable by addition or removal of a predictor variable on the criterion variable.

F change = is the variance due to manipulation of the factor divided by the variance due to error.