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Whether aptitude in physics, scientific attitude, and deep approach to study explain achievement in physics significantly – an investigation

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ABSTRACT: *In the present scientific society, achievement in physics has become one of the major parameters determining learners' quality. Achievement in physics is a complex variable having multidimensional construct. Various factors influencing learning physics explain its construct effectively. Present study has investigated whether this is explained by the factors aptitude in physics, scientific attitude, and deep approach to study. Four different dimensions of deep approach namely deep processing, relating ideas, use of evidence, and intrinsic motivation have been selected separately for this purpose. Major objectives of the study were to investigate relationship of these factors with achievement in physics both in the bi variate and multivariate levels. Students of class XII, studying different schools in West Bengal were selected as the sample. Their score in Physics of annual examination of class XI(conducted by WBCHSE) was considered as the indicator of their achievement in physics. Relationship at bi variate level was estimated using coefficients of correlation, and at the multivariate level using multiple regression analysis. At bi variate level, achievement in physics was found to be correlated strong and positively with aptitude in physics, scientific attitude, and also with two dimensions of deep approach- i.e. use of evidence, and relating ideas. At the multivariate level, these four factors aptitude in physics, scientific attitude, use of evidence, and relating ideas were also found to predict the criterion significantly. The dimension deep processing of deep approach though was found to be related with achievement significantly (fair and positively) at bi variate level, but at the multivariate level- it was found not to predict the criterion. The dimension intrinsic motivation of deep approach was found not a significant factor of achievement in physics in either of the levels.*

Keywords—*Achievement in physics, Aptitude in physics, Scientific attitude, Different dimensions of deep approach to study, Co efficient of correlation, Multiple Regression Analysis.*

I. INTRODUCTION

Revolution of science and technology has glorified the modern world in various ways. In fact, this revolution is the most important among the different newly emerging issues in the contemporary society. This has transformed the modern civilization into a scientific civilization.

In this context, science has become an integral part of our life and living. It is no longer confined to the eminent scientists. Rather, knowledge of science of an individual has become almost essential irrespective of his/her status. It is also considered as an important quality parameter of a school learner, in particular. Sound achievement in science does not only build the pillars on which the future success of an individual depends, it also provides him a scope to contribute significantly for the progress of nation. Among achievement in various disciplines of science, achievement in physics is the strongest predictor of future success of a learner, as well as the nation in view of tremendous utilitarian, cultural, and disciplinary values of the subject physics particularly.

Achievement in physics of a learner is the resultant of learning experiences of various kinds (Mukhopadhyay, 2012). It is a product variable and is influenced by several independent variables (Rao,1996), which are obviously the determinants of effective physics learning, as well.

Learning significantly depends on the unique traits and abilities of a learner determining their characteristics. Aptitude in physics and scientific attitude are few among these important factors, upon which physics learning depends to a great extent. Aptitude in physics helps a learner to apply skill and competency in learning science successfully and indicates the possibility of future accomplishment in the field of learning physics. Proper scientific attitude inclines a learner towards scientific knowledge, a scientific process, eminent scientists, and towards scientific inventions encouraging learner's spirit of scientific enquiry. Therefore, these may be two strong factors of achievement in physics. In addition to these, 'approaches to study' is also another factor influencing learning. Approaches to study determine the way through which learners interact with a

learning situation by receiving various information from surrounding and processing those. Effective approaches help learners to manipulate learning environment properly enriching their information processing system. Among different study approaches, defined by Ramsden and Entwistle (1983), deep approach particularly plays a significant role here. Deep approach determines learners' active engagement in attending to a learning situation orienting them properly to study. Deep approach seems meaningful particularly in the context of physics learning. Physics is characterized by its well organized structure of content. Several physics concepts are interrelated following a particular hierarchy. Therefore physics learning may be perceived by a learner, particularly by a deep learner, as an active search for the integrated whole in view of these interrelationships. He may investigate the related concepts from various aspects, combine those following systematic and logical approach, explores the meaningful whole ultimately. This may result in a reconstruction in his cognitive structure leading to an effective physics learning as a consequence.

Therefore, the conceptual framework, as discussed, indicates that aptitude in physics, scientific attitude, and deep approach to study are three important factors which may influence effective physics learning strongly leading to sound achievement. Hence, these three may be considered as the factors of achievement in physics.

Academic achievement in science has been investigated by researchers in relation to various correlates, among which aptitude and attitude in science have been considered by number of researchers. Alexander (1990) studied the influence of critical thinking, scientific aptitude, and socio-economic-status on achievement in science of secondary students. Results showed that all these three factors, particularly aptitude contributed significantly to achievement in science. Rao, (1996) investigated the relationship among scientific attitude, scientific aptitude, and achievement in biology of secondary students. Kerala University Scientific Aptitude Test constructed by Nair *et.al* (1968) and Scientific Attitude Inventory standardized by Sood and Sanadhya (1979) were used as tools. Aptitude, Attitude, and Achievement were found to be significantly related with one other. Kar (2004) found significant and positive association between attitude and achievement in general science. Mukhopadhyay (2012) investigated particularly Achievement in physics of higher secondary students (class XI); Aptitude in physics, and Scientific attitude were also considered by the researcher as two important factors. Test on Aptitude in Physics (Sen & Mukhopadhyay, 2008), Scientific Attitude Inventory (Sood and Sanadhya, 1979) were used as tools. Aptitude and Attitude both, particularly the former was found to explain a significant % variance of the scores on Achievement in physics. Studies therefore indicate that attitude and aptitude might be the factors which account for students' achievement in the discipline science in general, and in physics, in particular.

Sen (1995) investigated scholastic achievement in various subjects of secondary students in relation to various factors, among which learning strategy (construct of which resembles close similarity with the variable study approach, considered in the present study) was the important one. Deep learning strategy was found to predict achievement significantly in most of the subjects. Byrne *et al.*, 2002; Mattick *et al.*, 2004; Pimparyon *et al.*, 2000; Sadlo and Richardson, 2003; Stiernborg *et al.*, 1997 also have identified deep approach to study as significant factor of higher academic scores. Whereas, Diseth and Martinsen, 2003 have found no meaningful relationship between deep approaches to studying and achievement. The reason for the absence of a relationship is explained as being the characteristic overload of the curriculum towards examination procedures requiring little more than the reproduction of factual material to attain higher grades. Studies therefore indicate that deep approach might be a strong factor of achievement, but controversy exists in the view of researchers regarding the nature of that relation. Not only that, not even a single study has investigated achievement in relation to deep approach considering various dimensions of deep approach (deep processing, relating ideas, use of evidence, and, intrinsic motivation : Entwistle & Ramsden, 1983) separately.

Studies therefore indicate that, aptitude, attitude and deep approach are significant factors of achievement. Existing studies have investigated the relationship of scientific achievement with the three factors as mentioned, considering each of the factors separately or two of them together. Neither of the studies investigates scientific achievement in relation to these three factors considering them together. In such a study, different dimensions of deep approach to study may be considered as separate factors also. Such a multivariate analysis seem to explain the construct of the criterion variable in a more comprehensive manner. Hence is the scope of such investigation.

Following question has arisen in the mind of the present investigator in this context.

Whether the factors aptitude in physics, scientific attitude, and different dimensions of deep approach to study (deep processing, relating ideas, use of evidence, and, intrinsic motivation) significantly explain achievement in physics both in bivariate and in multivariate perspective?

Present study aims at finding the answer of this question. The study might have its significance in the context of physics learning in institution, particularly for a physics teacher in predicting achievement in physics of learners.

II. OBJECTIVES

Objectives of the study are as following-

(i) to investigate how does each of the factors among Aptitude in physics, different dimensions of Deep approach to Study (namely- Deep Processing, Relating Ideas, Use of Evidence, and Intrinsic Motivation), and Scientific attitude is related to achievement in physics at bivariate level.

(ii) to study how do these factors (all together) predict Achievement in physics in a multivariate perspective.

1. HYPOTHESES

Hypotheses are formulated according to the objectives, as stated. These are expressed in form of null hypotheses in view of inadequate number of related findings. Hypotheses are as follows.

H01: Achievement in Physics is not significantly correlated with each of the factors i.e. Aptitude in physics, Deep Processing, Relating Ideas, Use of Evidence, Intrinsic Motivation, and Scientific Attitude (at bi variate level).

HO2: Achievement in Physics cannot be predicted by the factors Aptitude in physics, Deep Processing, Relating Ideas, Use of Evidence, Intrinsic Motivation in physics, and Scientific Attitude (considered all of them together).

2. METHODOLOGY

4.1 Sample

Students of class XII, studying physics in different schools of West Bengal (under W.B.C.H.S.E) constituted the sample. Constitution is as follows:

Constitution of the sample

Category	Boy	Girl	Total
Urban	100	100	200
Rural	100	100	200
Total	200	200	400

4.2 Operational Description of Selected Variables

4.2.1. Achievement in Physics: In the present context, Achievement in physics has been operationalized in terms of students' score of physics in the annual examination of class XI (under WBCHSE).

4.2.2. Deep approach to study *(along with its different sub dimensions):*

Students using deep approach in study shows intention of understanding meaning of the lesson, interact actively with author's arguments, relate them to the previous knowledge and their own experience, and are motivated intrinsically.

Operational description of different sub dimensions included under deep approach is as follows:

4.2.2.1. Deep processing: active questioning in learning,

4.2.2.2. Relating ideas: relating new information to previous knowledge,

4.2.2.3. Use of evidence: relating evidence to draw conclusions, and

4.2.2.4. Intrinsic motivation: interest in learning for sake of learning itself.

4.2.3. Aptitude in Physics: Aptitude in physics is described operationally in relation to seven primary abilities namely scientific Information, Vocabulary in Physics, Number Series, Spatial Ability, Formulation, Verbal Comprehending and Interpretation, and Non-verbal (Mechanical) Interpretation.

4.2.4. Scientific Attitude: In the present study, scientific attitude is described operationally in terms of the following characteristics of a person (Sood and Sanadhya,1978): Rationality, Curiosity, Open-mindedness, Aversion to Suspension, Objectivity to Intellectual belief, and Suspended judgment.

4.3Tools

(i) Approaches to Study Inventory (ASI: Entwistle & Ramsden, 1983)- only the deep approach part

(ii) Test on Aptitude in Physics (Sen, & Mukhopadhyay, 2008).

(iii) Scientific Attitude Scale standardized by (SAS: Sood & Sanadhya, 1978)

(iv) Score in physics of class XI annual examination (Test prepared by W.B.C.H.S.E, which is as good as a standardized test).

4.4 *Design and Mode of analysis*

Step 1: Univariate level

Variables: Achievement in physics, Four different dimensions of deep approach to study, Aptitude in Physics, and Scientific attitude.

Mode of analysis: Descriptive statistics (Mean, S.D)

Purpose: For investigating sample primarily, nature of distribution of Scores and homogeneity of the sample

Step 2 : Bivariate level

Variables: Achievement in physics, Four dimensions of deep approach to study, Aptitude in Physics, and Scientific attitude

.Mode of analysis: Bivariate Correlation

Purpose: For estimating the coefficients of correlation of Achievement in Physics with each of the other selected variables

Step 3: Multivariate level

Variables: Dependent variable: Achievement in physics

Independent variables: Four different dimensions of deep approach to study, Aptitude in Physics, and Scientific attitude.

Mode of analysis: Multivariate regression analysis (Multiple regression and Step-wise regression)

Purpose: For investigating the level of prediction and degree of predictability of predictors for the criterion variable.

III. RESULTS OF DATA ANALYSES

Following steps were used for analyzing data

(a). Descriptive Analyses (Mean, Standard Deviation)

(b). Coefficients of Correlation

(c). Regression Analyses (Multiple Regression, Stepwise Regression).

These are discussed step by step as follows.

5.1* DESCRIPTIVE *Analysis (Mean, Standard Deviation,)

Mean and Standard Deviation (S.D) of the scores on each of the selected variables were estimated (in order to investigate sample primarily). These are presented in Table 1, as follows.

Table-1: Mean and Standard Deviation (S.D.) of Scores for Each of the Selected Variables (N=400)

Variables		Mean	S.D.
1.	Achievement in Physics	58.57	12.36
2.	Aptitude in Physics	45.68	8.64
3.	Scientific Attitude	108.47	14.33
4.	Deep processing	10.43	02.44
5.	Relating ideas	13.38	03.42
6.	Use of evidence	12.69	02.68
7.	Intrinsic motivation	9.77	01. 53

5.2 Coefficients of correlation

Coefficients of correlation of achievement in physics with each of the other variables were computed using Pearson's product moment method. Coefficients were estimated over the entire sample. Following table (Table 2) shows the results.

Table-2: Coefficients of Correlation of Achievement in Physics with other variables (N=400)

Variables	r
Achievement in Physics – Aptitude in Physics	0.702**
Achievement in Physics – Scientific Attitude	0.437**
Achievement in Physics – Relating Ideas	0.639**
Achievement in Physics – Use of Evidence	0.568**
Achievement in Physics – Deep Processing	0.153*
Achievement in Physics – Intrinsic motivation	0086N.S.

**** - significant at 0.01, **- significant at 0.01 level, * - significant at 0.05 level, N.S.-No Significance**

Results reveal that coefficients are significant at 0.01 level in case of the correlation of achievement in physics with aptitude in physics, scientific attitude, relating ideas, and with use of evidence; whereas this is significant at 0.05 level for the correlation of the same with deep processing. The dimension 'intrinsic motivation' of deep approach is found to have no significant co relation with achievement in physics. In view of this result, **hypothesis H01 is rejected and the alternate hypothesis that 'achievement in physics is significantly correlated with aptitude in physics, scientific attitude, relating ideas, use of evidence, and deep processing is accepted.**

5.3 Regression analysis

Interrelationship of achievement in physics with the other variables at multivariate level is investigated by using multiple regression analysis considering achievement in physics as the criteria variable and others as predictors. Stepwise regression analysis was also done subsequently. The regression analysis is used for investigating the level of prediction and degree of predictability of predictors for the criterion variable. Results are shown in the following tables (Tables 3A, Table 3B).

Table-3A. Summary: Multiple Regression Model Summary

Mode1	R	R-Square	Adjusted R-Square	Standard Error of Estimate	p
1.	0.713	0.508	0.503	15.499	0.000

Regression Coefficients

Model	Unstandardized Coefficients		Standard Coefficient	t	p
	B	Standard Error	Beta		
1. Constant	-54.842	17.254		-3.178	0.002
Relating ideas	1.540	0.192	0.361	8.067	0.000
Use of Evidence	0.529	0.099	0.238	5.589	0.000
Aptitude in Physics	0.748	0.166	0.199	4.568	0.000
Scientific attitude	0.678	0.155	0.178	3.852	0.000

Table 3B. Summary: Step-wise Regression

Multiple Regression	Step +in/-out	Multiple R	Multiple R^2	R-square change	p-level
Relating ideas	1	0.5911	0.3489	0.3489	0.0000
Use of evidence	2	0.6878	0.4732	0.1243	0.0000
Aptitude in Physics	3	0.7110	0.5055	0.0323	0.0000
Scientific attitude	4	0.7130	0.5083	0.0025	0.2441

Analyses of multiple regressions (Table 3A) showed that regression model predict 50.8 % of variance of scores of achievement in physics. Results of step-wise analyses (Table 3B) showed that major % of the variance are explained by the variables namely- Relating ideas, Use of evidence, and Aptitude in physics. Scientific attitude is found to be a significant predictor, though of relatively low strength. Two particular dimensions of deep approach, i.e. deep processing and intrinsic motivation are found not to predict the criterion significantly. In view of this result, **null hypothesis H02 is rejected and the alternate hypothesis that 'achievement in physics is significantly predicted by Relating ideas, Use of evidence, Aptitude in physics, and Scientific attitude' is accepted.**

IV. DISCUSSION

Results indicate that two particular dimensions of deep approach that is 'relating ideas' and 'use of evidence' are strong and positively interrelated with achievement in Physics, at bivariate level. These two dimensions are also found to predict the criteria variable very significantly (explaining 34.9%, and 12.43% variance of scores respectively, Table 3B) in the multivariate perspective. Cognitive school of psychology explains learning in terms of construction of knowledge of learner. In the context of science these two

dimensions of deep approach seem to be associated with such knowledge construction very closely. Relating ideas may help a learner to integrate related concepts into a meaningful whole forming newer and newer 'gestult'. Use of evidence helps them in verifying results conducting suitable experiments. All these are in favor of effective physics learning ensuring a sound achievement in Physics. This might account for the result. Besides these two dimensions of deep approach, aptitude in Physics is also found to be a significant factor of achievement (having strong relationship both at the bivariate and multivariate level). The present study has operationalized aptitude in physics in terms of different primary mental abilities (discussed under section 4.2.3) which also seem to be effective in developing learners' fundamental concepts in physics leading to their sound achievement.

Scientific attitude is found to be associated with achievement fairly and positively. It is also found to be a fair predictor of the criteria. Scientific attitude orients a learner towards various aspects of learning science, and in physics particularly. Various operational dimensions of scientific attitude, considered in the present study (section 4.2.4) in fact are steps of a scientific method which learners use in their science learning. The dimension curiosity arises learner desire for understanding new situations, open mindedness encourages his/her willingness to revise opinion resulting in restructuring of knowledge, suspended judgment encourages his/her ability of concluding on the basis of sound evidence. These might enable a physics learner in applying the proper steps of learning physics resulting in sound achievement.

Two particular dimensions of deep approach that is 'deep processing' and 'intrinsic motivation' are found not to be the strong factors. Deep strategy encourages learners active participation in learning nurturing his/her spirit of scientific enquiry. Its correlation at bivariate level with achievement is found to be significant only at 0.05 level (Table 2). The achieving learners might have deep orientation but due to some situational causes as heavy load of curriculum, over emphasis on factual and informative physics learning etc. may result in their inability in applying that orientation properly in learning physics. Therefore in spite of being a moderately significant factor at bivariate level, it fails to be a significant predictor at multivariate level. The dimension intrinsic motivation of deep approach is found to be related with achievement insignificantly both in bivariate and multivariate perspective (Table 2, table 3). Intrinsic motivation provides a learner joy in constructing new knowledge. Learning of an intrinsically motivated learner is driven by his/her personal interest for the sake of learning itself. Learning of achieving students perhaps was externally motivated. Present study has considered students of class XII as the sample. This is the higher secondary level where physics learners particularly start preparing themselves for getting admitted in various vocation oriented courses. This trend probably has made their learning more achieving and product oriented (in terms of getting suitable placement). This might account for the result of failure of intrinsic motivation to be related with achievement significantly, as is obtained in the present study.

V. CONCLUSION

Results reveal that aptitude in physics, scientific attitude, and two particular dimensions of deep approach to study namely- relating ideas, and use of evidence are strong factors of achievement in Physics. These factors have significant co-relation with achievement in Physics in bivariate level. They also predict achievement strongly in the multivariate level. The dimension deep processing of deep approach to study is though co-related with achievement with Physics significantly but fails to predict the criteria in the multivariate perspective. The dimension intrinsic motivation only is found not to be a significant factor.

These results indicate some particular trends of achieving learners in Physics. Their learning emphasizes on inter-relating various ideas in Physics. They have sense of logic and preference of finding fact before concluding anything. They are also oriented towards learning science and have potential to accomplish success in future life in learning physics. To some extent they have meaning orientation in Physics learning but in spite of this they might not have enough scope to appreciate the beauty in learning Physics and as a consequence they fail to enjoy this learning being intrinsically motivated. Their spirit of scientific enquiry and urge for knowledge construction might not be properly encouraged in the physics classroom which is highly controlled by the teacher. Over loaded curriculum, undue emphasis of achievement in examination without due concern to proper understanding, and moreover inadequate exposure in learning Physics (as they have started learning physics as a separate discipline from class XI) particularly may be the probable causes which might de motivate them to feel the strong urge for learning physics for the sake of learning itself and also discourage them from active participation in learning the same.

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