Prediction of Class 12 Physics Scores: Does Gender Matter?

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The main objective of the investigation was to find out whether the prediction of physics scores of class 12 students differs by gender. The sample consisted of 407 students (248 boys, 159 girls) studying in class 12 (science stream) at Kendriya Vidyalayas (Central Schools) of Kolkata city and its suburbs. The procedure of sample selection was a two-step process. In the first step the technique of area sampling was employed to randomly select 7 Kendriya Vidyalayas of Kolkata region followed by random selection of class 12 science students from these schools. In the second step a socio-economic status (SES) scale was administered to these pupils to screen and include only those belonging to middle SES families in the final sample. Then standardized tools were administered to the students in the final sample for assessing their psychological attributes. Pupils' physics examination scores were noted from the school records. Multiple Regression Analyses and ANOVA revealed significant gender difference in prediction of physics scores on the basis of student attributes.

Keywords: Prediction of achievement, Physics, Gender difference, Student attributes

Introduction

Gender differences in student attributes and academic achievement have been extensively researched. But studies on the gender differences in prediction of achievement are rare especially in the Indian context. There is under-representation of female students in science education (Chandra et al., 2009; Hazari & Potvin, 2005). So it is imperative to discover the gender differentials in prediction of science achievement. It may help bring about gender equity. The gender differences in prediction of achievement in each science subject at every educational level have to be studied separately. This would prevent confounding. Investigations on the influence of gender, if any, on the prediction of achievement in physics are of particular interest. This is because physics is considered a masculine subject (Hazari & Potvin, 2005; Sadker & Zittleman, 2010).

Witt (1994) highlighted the paucity of researches on the gender differential prediction of achievement of adolescents. So it appears to be a relatively uncharted area of research. There are few investigations looking for the gender differences in the prediction of science (especially physics) achievement of school students. These generally confirm the existence of such differences (Dimitrov, 1999; Guidubaldi, 2009; Ignatz, 1982; Khan, 2005; Witt, 1994; Wolf & Fraser, 2008). A minority of studies negate the gender differentials. Irrespective of the nature of findings, the rationales given are illuminating. Li, Shavelson, Kupermintz, and Ruiz-Primo, (2002) reported negligible differences between girls' and boys' (TIMSS data) mean mathematics and science scores. But they found that the pattern of relationships between mathematics and science scores differed by gender. However the prediction of science achievement on the basis of that in mathematics did not differ by gender. Lewis and Hoover (1987) also found the mean verbal, quantitative and non-verbal ability scores to be similar for boys and girls. But gender differences in prediction were discovered. Thus it seems that gender difference in prediction neither solely depends on gender differences in predictors and dependent variables nor on the gender differences in the associations among these variables. Besides, there is the question of precision of prediction. For instance, Lewis and Hoover (1987) stated that girls' scores on reading, reference materials and language skills tests were consistently under-predicted for a sample of 2nd, 5th and 8th graders. But Witt (1994) reported the over-prediction of 8th and 9th grade girls' science scores. This paradox may be attributed to the differences in the nature of samples, the domains and the measures used.

Khan (2005) conducted a factor analytic investigation on samples of higher secondary students (200 boys, 200 girls) in India. The aim was to establish the prognostic value of select predictors. She concluded that the attributes of high achievers in science differed by gender. The boys were impulsive, suspicious, shy, fickle minded, dominant and of low socio-economic status. The girls were stable, trusting, venturesome, persevering, submissive and of high socio-economic status. Similarly Guidubaldi (2009) observed significant gender differences in the strength of ecological and personal predictors of 9th graders' science achievement as well as those in the composition of the best predictor models. It also appears that student attributes interact with educational variables resulting in gender differentials. Dimitrov (1999) reported that boys of high ability did better than their female counterparts on the open-ended evaluation formats in physical sciences. Wolf and Fraser (2008) concluded that inquiry based laboratory activities were differentially effective for male and female students. Cavallo, Potter and Rozman (2004) found different variables (of learning and motivation) to be important for achievement of men and women in inquiry-based physics; reasoning ability facilitated women's achievement, learning goals and rote learning were detrimental for the men.

The inherent and socialized differences between the genders as well as the masculine culture of physics (Hazari & Potvin, 2005; Sadker & Zittleman, 2010) may be responsible for gender differentials in prediction of physics achievement. Researches have indicated that males are reportedly superior in visual-spatial skills while females are better in verbal skills (Halpern & LaMay, 2000; Maccoby & Jacklin, 1978). Boys tend to be more competitive and evaluate their academic abilities higher than those of girls who tend to be more cooperative and lack self confidence in their capabilities to master physics. This is perhaps because they are made to believe that physics is a male domain, and are not encouraged to study physics. The male–bias of the physics curricula and textbooks is also disadvantageous for girls as is the classroom interactions that generally favour boys, and marginalize girls (Hazari & Potvin, 2005; Sadker & Zittleman, 2010). Khan's (2005) study was the only one among those surveyed which was conducted in the Indian context. Its overall result agrees with most of those conducted in the West.

The specific context of the present study is Kolkata (formerly Calcutta). It is the capital of the Indian state of West Bengal and a city with a colonial past. It has a rich tradition of education and culture. Historically education had been a male preserve in Bengal. Socio-religious prejudices obstructed women's education. Modern education was introduced in the early 19th century by the British rulers in Calcutta. The aim was to train Indian men to serve the colonial administration, to imbibe western culture and science. Schools for girls were founded much later in Calcutta to socialize them only to become western-influenced homemakers. Girls from elite families attended these schools whereas most girls remained uneducated. The reform and nationalist movements emphasized greater inclusiveness and respect for Indian culture in education. Even then males benefited much more from such education as these movements generally supported patriarchy in matters of women's education. Even after India's independence educating women implied the improvement of their marriage prospects. Later it was realized that women's education could generate more income for the family. Thus education of women did not necessarily result in their empowerment. Besides they still lag much behind men in all indices of education despite upswings in women's education and in their entry into non-traditional disciplines (e.g., science and technology). But patrifocal attitudes continue to limit women's access to education even among middle class urban residents of Bengal (Kerkhoff, 1998; Mukhopadhyay & Seymour, 1994).

Research Study

Hypotheses

H_{01}: There are no differences between the means of the attribute scores of boys and girls.

H_{02}: There are no differences between the regression co-efficients of the gender- groups.

H_{03}: There is no difference between the predictions of boys' and girls' class 12 physics scores.

Methodology

Sample

The sample consisted of 407 students (248 boys, 159 girls) of 17 through 19 years studying in class 12 (science stream) at Kendriya Vidyalayas (Central Schools) of Kolkata and it's suburbs. There is a network of Kendriya Vidyalayas run by the Government of India all across the country and at some locations abroad. These schools are affiliates of the Central Board of Secondary Education following uniform syllabus, textbooks, and methods of teaching, evaluation and administration. The technique of area sampling was adhered to for the first phase of sample selection, i.e., random selection of seven Kendriya Vidyalayas located at different geographical zones in the Kolkata region followed by random selection of students from each of these schools. In the second phase a socio-economic status (SES) scale was administered to the selected students to include only those belonging to middle SES families in the final sample. The pupils of higher and lower SES families were excluded from the sample. This was done to control the extraneous variable of SES. Although it had been planned to include equal numbers of boys and girls in the sample, yet there are more boys in the sample than girls. This is because boys were found to outnumber girls in higher secondary science stream in the Kendriya Vidyalayas of Kolkata region.

Tools

The standardized tools (Table 1) were administered to the students to assess their attributes. Data were collected from small groups of about 20 pupils each at a time. Sessions of data collection from each group were spread over three days. Students' class 12 half-yearly examination *physics* (theoretical paper) scores *(Phy)* were considered as the achievement variable and noted from the school records.

Sr. No.	Standardized Tools	Variables Assessed
1	Scientific Knowledge and Aptitude Test, Form 1064 (Chatterji & Mukherjee, 1964)	Scientific Knowledge & Aptitude (SKA)
2	NIIP Non-Verbal Group Test 70 (National Institute of Industrial Psychology, 1968)	Intelligence (Int)
3	Group Embedded Figures Test (Oltman, Raskin, & Witkin, 1971)	Field-Dependence-Independence (F-D-I)
4	Palsane and Sharma Study Habits Inventory (Palsane & Sharma, 1989)	Study Habits (SH)
5	Mohsin Self Concept Inventory (Mohsin, 1979)	Self Concept (SC)
6	Eysenck Personality Inventory, Form A (Eysenck & Eysenck, 1964)	Neuroticism (N) & Extraversion- Introversion (E-I)
7	Socio - Economic Status Scale (Urban) Form B (Kuppuswamy, 1984)	Socioeconomic Status for control

Table 1: Standardized tools used

Statistical Analysis

Z tests, Multiple Regression Analyses and ANOVA were conducted. BMDP and SPSS packages were used.

Results and Discussion

Variables	Boys (248)		Girls (159)		Total (407)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
SKA	43.87	11.15	44.87	11.36	44.26	11.23
Int	60.57	7.75	59.77	8.75	60.26	8.16
F-D-I	9.21	3.04	9.88	3.06	9.47	3.06
SH	54.82	13.92	52.69	13.14	53.99	13.65
SC	29.30	5.77	29.33	5.89	29.31	5.81
N	11.94	2.90	11.63	2.88	11.82	2.89
E-I	11.92	3.61	11.74	3.56	11.85	3.59
Phy	55.00	16.76	51.63	17.68	53.68	17.18

Table 2: Descriptive statistics

Statistic	Attribute Variables						
	SKA	Int	F-D-I	SH	SC	N	E-I
Z	-0.88	0.94	-2.09	1.55	-0.05	1.11	0.50

$p < .01$

Table 3: Results of z test: Significance of difference between means of gender groups

Table 2 shows that the boys and girls are almost similar in the means and standard deviations of the attributes and the achievement variable. Table 3 reveals that none of the differences between the means of boys and girls for each of the attributes is significant ($p < .01$). So H_{01} is accepted. This agrees with the findings of Lewis and Hoover (1987) and Li et al., (2002). The disparate sizes of the gender-groups (Table 2) highlight the under-representation of females in science education particularly in India (Chandra et al., 2009; Hazari & Potvin, 2005).

The relationship between *Physics* and each attribute for the gender-groups is depicted in the form of scatter plots in Appendix. It is apparent that for both boys and girls there are positive associations between *Physics* on the one hand and *scientific knowledge and aptitude, intelligence, field-dependence-independence* and *study habits* on the other. The inverse relationships between boys' and girls' *physics* and *neuroticism* as well as *extraversion-introversion* are also observed. For both boys and girls there is little association between *physics* and *self concept*.

Variables	Regression Coefficient	Standard Error
SKA	0.65	0.12
Int	0.19	0.13
F-D-I	1.04	0.33
SH	–0.10	0.10
SC	0.10	0.15
N	–0.40	0.30
E-I	–0.50	0.27
Intercept = 18.05; R = 0.62**; **p< .01 R2 = 0.38 F = 21.37** (7, 240)		

Table 4: Results of regression: Physics scores (dependent variable) of boys (248)

Variables	Regression Coefficient	Standard Error
SKA	0.24	0.14
Int	0.54	0.14
F-D-I	0.99	0.41
SH	0.33	0.12
SC	-0.19	0.18
N	-0.04	0.37
E-I	-0.41	0.33
Intercept = -7.53; R = 0.71**; **p< .01 R2 = 0.51 F = 22.30** (7, 151)		

Table 5: Results of regression: *Physics* scores (dependent variable) of girls (159)

Table 4 reveals that 38% of the variance in the boys' *physics* scores can be predicted on the basis of the select student attributes. The F value indicates that the regression is highly significant. Table 5 shows that as much as 51% of the variance in the girls' *physics scores* can be predicted by the attributes. The regression is consequently strongly significant.

Statistic	Predictors						
	SKA	Int	F-D-I	SH	SC	N	E-I
Z	2.80**	-1.80	0.20	-3.20**	1.00	-0.60	-0.30

**p< .01

Table 6: Results of z test: Significance of gender difference between regression coefficients

Table 6 reveals that the boys' and girls' regression coefficients differed significantly only in case of *scientific knowledge and aptitude* and s*tudy habits*. So H_{02} is partly accepted.

Regression analysis was also conducted with *physics scores* (dependent variable) of all the 407 students. The value of the intercept was found to be 6.82. The R was 0.64 and the R2 was found to be 0.40. The F value was 38.64 (df 7, 399). So the R and F values were significant (p< .01). Forty percent of the variance in the boys' and girls' *Physics* can be accounted for by the predictors. The regression is highly significant.

Source of Variation	Sum of Squares	Mean Square	F
Regression by groups	4412	551.50	3.22** (8,391)
Residual	67038.48	171.45	

**p< .01

Table 7: Results of ANOVA: Regression by gender – groups

Inspection of Table 7 reveals that the regression equations of the samples of the boys and the girls differ significantly. Thus H_{03} is rejected; the alternative hypothesis is upheld. So it seems justified to treat the boys and girls separately for developing the regression equations. The result is congruent with those reported by Dimitrov (1999), Guidubaldi (2009), Ignatz (1982), Khan (2005), Witt (1994) and Wolf and Fraser (2008).

Scrutiny of Table 4 shows that for the boys, possession of higher *field-dependence-independence* as well as s*cientific knowledge and aptitude* and lower levels of *neuroticism* and e*xtraversion-introversion* facilitates *physics scores*. Table 5 shows that for girls, having higher *field-dependence-independence*, *intelligence* and s*tudy habits* as well as lower e*xtraversion-introversion* aids *physics*. *Intelligence, study habits* and s*elf concept* are weaker predictors for the boys. *Scientific knowledge and aptitude, self concept* and specially *neuroticism* do not contribute much to the prediction among girls. Better *study habits* promote *physics* of girls but not boys. So *field-independence* and *introversion* have been found to be responsible for higher *physics scores* of both the genders. Boys and girls have similar means in s*cientific knowledge and aptitude* (Tables 2 and 3). But girls' *scientific knowledge and aptitude* play less decisive role in accounting for their *physics scores* than that of the boys. It is because girls trust their s*cientific knowledge and aptitude* less. The reasons could be patrifocal attitudes and the consequent gender-discriminatory socialization. Patrifocal attitudes are prevalent in Kolkata and elsewhere in India (Mukhopadhyay & Seymour, 1994). These devalue girls' s*cientific knowledge and aptitude*. Gender-discriminatory socialization tries to exclude females from science education (Hazari & Potvin, 2005; Sadker & Zittleman, 2010). Thus girls appear to rely more on their *intelligence* and *study habits* for their *physics scores*. Again, despite having similar mean *neuroticism* levels (Tables 2 and 3), the *physics scores* of boys depend heavily on their *neuroticism* unlike those of the girls. This may be because the patrifocal society (Mukhopadhyay & Seymour, 1994) expects boys to excel in physics as it is considered masculine (Hazari & Potvin, 2005). It makes boys with higher *neuroticism* particularly anxious. So they can not access their store of scientific knowledge efficiently and impairs their *physics performance*. Differences in the magnitudes and directions of the intercepts for the two genders (Tables 4 and 5) indicate that the elevations of the regression lines are very different. Even the proportion of the variance of *physics scores* which could be predicted is much higher for girls than that for boys. So it appears that somewhat different combinations of predictors are important for prediction of *physics performance* of the two genders. The results are in tandem with results reported by Cavallo et al., (2004), Dimitrov (1999), Guidubaldi (2009) and Khan (2005).

Conclusion

The means of the boys' and girls' scores on the attributes do not differ significantly. The regression coefficients of s*cientific* *knowledge and aptitude* and s*tudy habits* show significant gender difference. The predictions of class 12 physics scores on the basis of select student attributes appear to differ by gender. The following suggestions are made on the basis of the study; separate models of prediction of achievement in physics for the two genders are required, inclusion of academic rather than general self concept as a predictor may enhance the magnitude of prediction of physics achievement, and girls need to be socialized to value their scientific knowledge and aptitude while boys need to be taught to value their study habits and not be pressurized to excel in physics.

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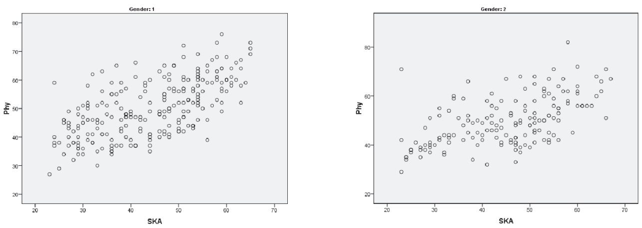
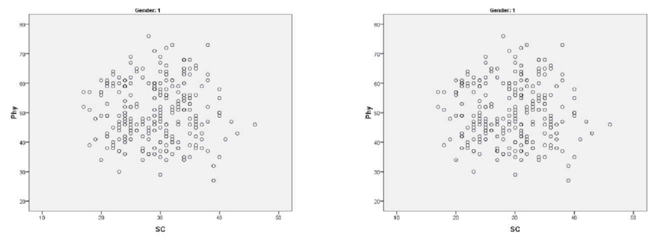
APPENDIX

The relationship between *Physics* and each attribute for the gender-groups in the form of scatter plots.

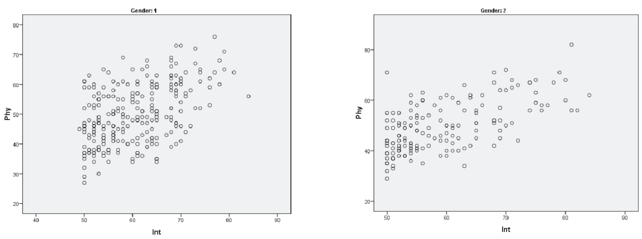
Boys	**Girls**	**Boys**	**Girls**



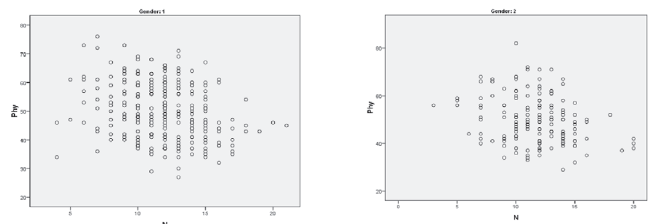
Scientific Knowledge and Aptitude (SKA)



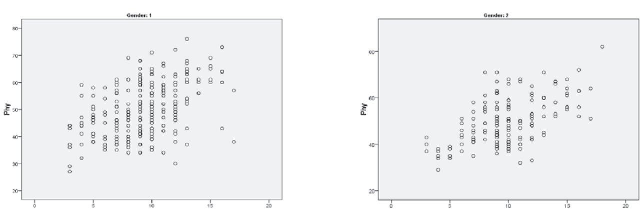
Self Concept (SC)



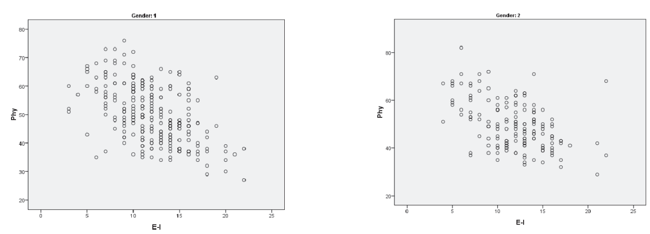
Intelligence (Int)



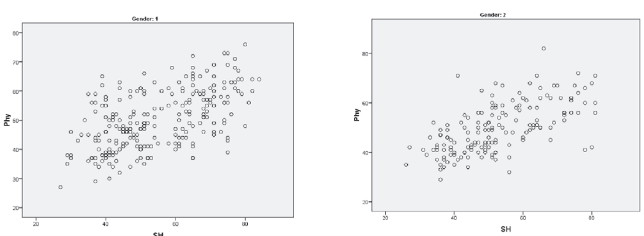
Neuroticism (N)



Field-Dependence-Independence (F-D-I)



Extraversion-Introversion (E-I)



Study Habits (SH)