Exploring Gender Disparities in Science Achievement

The Impact of Student Engagement among Secondary School Students in West Bengal

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Abstract

This research is a cross-sectional survey that investigates the influence of student engagement on science achievement. Multistage sampling procedures were used to determine the sample of secondary school students (n = 1232). The responses from the respondents were gathered using the student engagement in learning scale and end-of-year examination marks in physical science subject were considered as science achievement. Confirmatory factor analysis and moderation analysis were utilised for data analysis. The findings indicate that there is a significant relationship between student engagement and science achievement. The results show that emotional sub-scale is a better predictor of science achievement ($\beta = 0.23$, $p<0.05$), than behavioural sub-scale ($\beta = 0.32$, $p<0.05$), and cognitive sub-scale ($\beta = 0.38$, $p<0.05$). Thus, this study suggests that school administrators and instructors need to plan and implement interesting activities to increase student engagement.

Keywords: *Emotional engagement, cognitive engagement, behavioural engagement, science achievement, student engagement*

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Introduction

Recognising that the adolescents who are not invested in their schoolwork or their futures are more likely to struggle in the classroom, to drop out of school, and to engage in negative behaviours (Fredricks, Blumenfeld, and Paris, 2004), their low levels of school engagement have been an urgent concern for educators and policymakers. From a developmental viewpoint, disinterest in schooling is a cumulative process that culminates in academic failure and dropping out (Randolph, Fraser, and Orthner, 2004). In this way, increasing student engagement could protect against such negative outcomes.

Students' aptitude, attitudes and perspectives, socioeconomic characteristics, family and peer influences and school-related variables have been shown to affect their performance in science in secondary school (Singh, Granville, and Dika, 2002). Researchers may not be able control or regulate many of these factors as they pertain to the home and the family. However, educational interventions have the potential to affect and improve several school-related factors like students' engagement, their beliefs and attitudes and their understanding of the relevance of science achievement in future career options. Therefore, there has been a lot of focus in recent years on attempting to figure out how variables like motivation, attitudes and academic engagement affect performance in science.

Student Engagement

Student engagement has been proven to be an important variable that influences several educational outcomes like students' achievement, their interest in learning, life satisfaction and self-regulation. Student engagement in learning refers to the active involvement, enthusiasm and commitment demonstrated by students towards their educational experiences (Sharma and Bhaumik, 2013; Shrivastava and Shrivastava, 2022). Engaged students are deeply absorbed in the learning process, eagerly participating in class discussions, completing assignments with diligence and seeking out opportunities for further exploration. Engaged learners demonstrate curiosity, motivation, and a genuine interest in the subject matter, which fosters a positive learning environment and enhances academic achievement.

Student engagement (Fredricks, Blumenfeld, and Paris, 2004) is a meta-construct comprised of three different types of factors— cognitive, emotional, and behavioural. Students' levels of engagement can be broken down into three categories— cognitive, emotional, and behavioural. The term cognitive engagement describes how hard students strive to learn, including how much time they spend studying, how much they like to learn, how much they want to learn beyond

what they already know, and how they learn independently (Singh, Kumar, and Srivastava, 2020). Behavioural engagement describes how students behave in the classroom, including how they listen intently to others, pay attention to teachers, ask questions, participate in class discussions, share opinions, argue points of view, seek clarification, ask for help and maintain classroom regulations (Singh, Kumar, and Srivastava, 2020). Further, students who are emotionally engaged are those who feel that they belong in the classroom, as shown by their enjoyment of learning in the classroom, their connection to their classmates and their attitudes towards the instructors.

Student Engagement and Academic Achievement

Academic success may be boosted by students' active participation in class and class activities (Wang, et al., 2016). Engaged students tend to do better in school as many studies have shown (Deveci and Karademir, 2019). Recent and past research (For example, Carini, Kuh, and Klein, 2006; Delfino, 2019) have examined the correlation between student engagement and academic success. The connection between student engagement and academic success has been disentangled in previous research. According to the research (Heng, 2013), there is a strong correlation between active learning and academic success. Academic success is correlated with students' use of effective learning strategies (Park, 2005). Previous studies (For example, Wong, Lam and Kong, 2003; Asif, Thomas, Awan and Din, 2020) have revealed a correlation between students' levels of behavioural engagement and their performance in the classroom. Academic success may be affected by factors such as diligence, which is a measure of behavioural engagement. As a result of their engagement in learning, diligent students tend to perform better in class.

The majority of research on the correlation between student engagement and academic success has used a multi-factor approach, measuring both emotional and behavioural facets of engagement (Borman and Overman, 2004). It is unclear how much of an impact students' emotional engagement has on their grades. However, Willms (2003) and Finn (1993) found that school identity and a feeling of belonging did not reliably predict academic achievement.

Examining various components of student engagement yields different conclusions on the impact of engagement on academic success. Willms (2003) found that students' attendance and punctuality, which he described as behavioural engagement, were moderately correlated with their level of educational attainment. Academically resilient adolescents seem to benefit more from behavioural engagement than other students (Borman and Overman, 2004). For

instance, Borman and Overman (2004) found that students who were academically resilient, as defined by having higher than predicted mathematics scores were engaged in more academic activities.

Gender Gap in Science Achievement

For almost 20 years, there has been a consistent worldwide gender disparity in TIMSS results regarding science achievement, with boys consistently outperforming girls (Meinck and Brese, 2019). Student achievement in science has been shown to vary by gender in many studies (For example, Chang, 2008; Preckel, et al., 2008). Studies examining the correlation between gender and academic success have shown that males generally outperform girls in science (For example, Martin et al., 2000).

For a long time, researchers and policymakers have been worried about the 'gender gap' in student achievement (UNESCO, 2015a). The pursuit of parity between the sexes in all areas may seem utopian. However, goals for equality and equity in access to educational facilities are at the heart of educational policy across the world. Further, achieving gender equality has emerged as a political priority and a standard of fairness, especially in the realm of education. The United Nations has included achieving gender equality in its list of sustainable development goals (UN, 2018, UNESCO, 2015b).

The Present Study

The present study focused on two objectives:

1. To determine the relationship between three student engagement dimensions (viz., cognitive, behavioural, and emotional engagement) and the science achievement of secondary school students.
2. To determine whether students' gender moderates the relationship between three student engagement dimensions (viz., cognitive, behavioural and emotional engagement) and science achievement.

The first research objective focused on examining the influence of three student engagement dimensions on science achievement and to measure the effects of those three predictors on students' science achievement. Thus, the teachers may be aware of those significant predictors to enhance students' achievement in science. Further, the second objective investigated whether gender gap in student engagement results in the gender difference in science achievement. Thus, the following hypotheses were formulated:

Hypothesis 1 (H_1): There is a significant relationship between three student engagement dimensions (viz., cognitive, behavioural and emotional engagement) and the science achievement.

Hypothesis 2 (H_2): Students' gender moderates the relationship between

three student engagement dimensions (viz., cognitive, behavioural and emotional engagement) and science achievement.

Methods and Procedures

Respondents of the Study

A cross-sectional survey was administered to a sample of secondary school students (10th graders) in West Bengal, India. There were 1232 respondents from 41 government secondary schools under the regulation of the West Bengal Board of Secondary Education (WBBSE). The schools were randomly selected from seven districts of West Bengal (viz., Nadia, Cooch Behar, Purba Burdwan, Birbhum, Murshidabad, Hooghly and North Dinajpur). The medium of communication and instruction was Bengali. Among the respondents, 621 were males and 611 were females (Table 1). Among the schools, 19 were located in rural areas whereas 22 were located in the urban areas. The average age of the students were 15.64 years with standard deviation of 0.42.

Method

The present study attempted to speculate the relationships among the three variables namely, gender, student engagement and students' achievement in (physical) science in the context of secondary schools classrooms in West Bengal. Therefore, survey research method was found suitable for the study.

Table 1: Respondents' Details

	Sample with Specifications (1232 Participants)	
	N	**%**
Gender		
Male	621	50.41
Female	611	49.59
District-wise distribution of the respondents		
Purba Burdwan	172	13.96
Nadia	176	14.29
Birbhum	177	14.37
Hooghly	179	14.53
Murshidabad	171	13.88
Cooch Behar	173	14.04
Malda	184	14.94

Note: Aggregates of percentages of different categories may not produce 100 per cent due to approximation up to two decimal figures.

The interrelations among the study variables were tested using primary (quantitative) data collected from the secondary school students.

Measurements

Student Engagement in Learning Scale (SELS)

Student engagement was measured using the 'student engagement in learning scale' (SELS). The scale was developed by Pal and Roy (2022). The scale considered student engagement as a three-dimensional construct with cognitive (7 items), behavioural (8 items) and emotional engagement (8 items) sub-scales. The tool consists with 23 scale items (11 negative items) to be rated on a 5-point Likert scale (starting from score 1 for 'strongly disagree' to score 5 for 'strongly agree'). The instrument was validated on 617 secondary school students. The factorial validity was established and the split-half reliability coefficient was 0.89. Further, the internal consistency reliability coefficients were 0.90, 0.92 and 0.92 for cognitive, behavioural and emotional dimensions, and 0.88 for the overall scale.

Science Achievement

The end-of-year examination (i.e., *madhyamik pariksha*) marks in Physical Science subject were considered as the science achievement of the students. The achievement of the students was collected from the office records of the respective schools.

Data Collection

The data collection was conducted following certain formal and ethical protocols. Firstly, the head of the institutions were approached to inform about the present study and were also requested to cooperate during data collection. The students were also informed about the purpose of the present study. Students who agreed to respond voluntarily, were provided with the questionnaire namely, student engagement in learning scale. Finally, students' achievement in physical science was collected from office records.

Data Analysis

The analysis was conducted in four stages. First, with the use of SPSS, calculations were carried out for the means (M) and standard deviations (SD) of three engagement dimensions. Second, using Confirmatory Factor Analysis (CFA) and maximum likelihood estimation, the three-factor measurement model was verified. Third, in order to ascertain the hypothesised relationships between the three engagement dimensions, Structural Equation Modeling (SEM) was implemented. Finally, three moderation analyses were performed to examine the differential effect of three engagement dimensions on science achievement of boys' and girls'.

Results

The Measurement Model

Student Engagement

The second-order confirmatory factor analysis showed that the 23-item student engagement model consisted of three factors with acceptable fit (x2 = 358.74; df = 227; p<0.001; TLI = 0.92; CFI = 0.94; SRMR = 0.063, and RMSEA = 0.056). The factor loadings of the items varied from 0.72 to 0.92. The descriptive results showed that the participants gave higher rankings to their emotional engagement. Specifically, emotional engagement (M = 25.31, SD = 4.27) ranked as the highest mean score, followed by cognitive engagement (M = 23.39, SD = 5.33), and behavioural engagement (M = 22.67, SD = 3.41). The reliability coefficient values were 0.89, 0.91, and 0.87, for cognitive, behavioural, and emotional sub-scales and 0.87 for the overall scale which indicated a satisfactory level of internal consistency. Factor inter-correlations were indicating relative independence of the three engagement dimensions (Table 2).

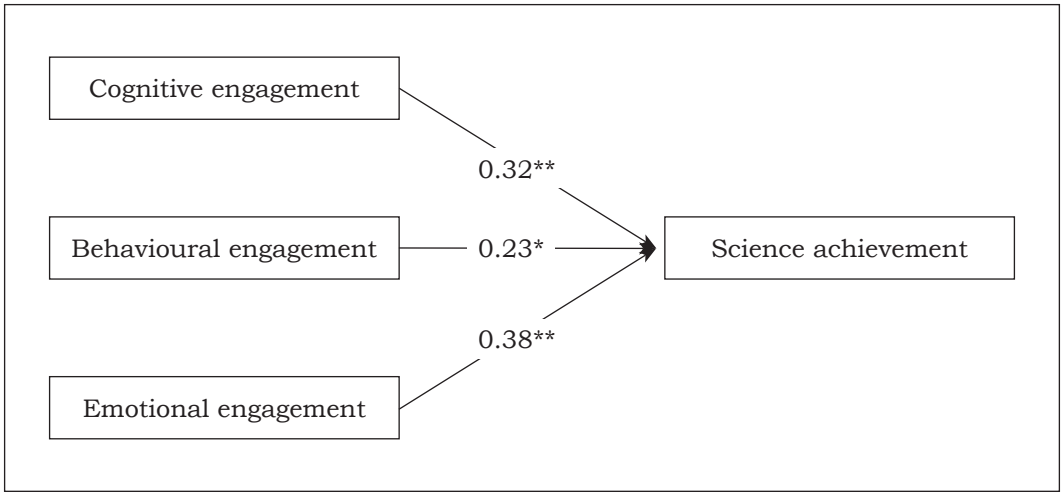
Table 2: Descriptive Statistics for Cognitive, Behavioural and Emotional Engagement Sub-scales (n = 1232)

Scale	Student Engagement in Learning Scale (SELS)		
	Cognitive Engagement	Behavioural Engagement	Emotional Engagement
Cognitive engagement			
Behavioural engagement	0.42**	-	
Emotional engagement	0.36**	0.34**	-
M	23.39	22.67	25.31
SD	5.33	3.41	4.27
Cronbach's α	0.89	0.91	0.87

**Significant at 0.05 level*
***Significant at 0.01 level*

The Structural Model

A structural equation model was established in response to the three hypotheses after testing all regression paths from trust in schools to emotional well-being and job performance. The final structural model had a good model fit to the data (x^2 = 5.52(3), p<0.01; CFI = 0.93; TLI =0 0.91; RMSEA = 0.057; SRMR = 0.061). Overall, this model demonstrated that three student engagement dimensions positively affected science achievement (Fig. 1).



**Significant at 0.05 level*
***Significant at 0.01 level*

Fig. 1: The structural model

The structural model identified three regression paths leading from three engagement dimensions to science achievement. In response to Hypothesis 1, all three student engagement significantly and positively affected science achievement. Specifically, student engagement had three significant regression paths with three dimensions (cognitive engagement: β = 0.32, $p<0.05$; behavioural engagement: β= 0.23, $p<0.05$; emotional engagement: β = 0.38, $p<0.05$). Thus, the hypothesis (H_1) was verified.

Results of Moderation Analysis

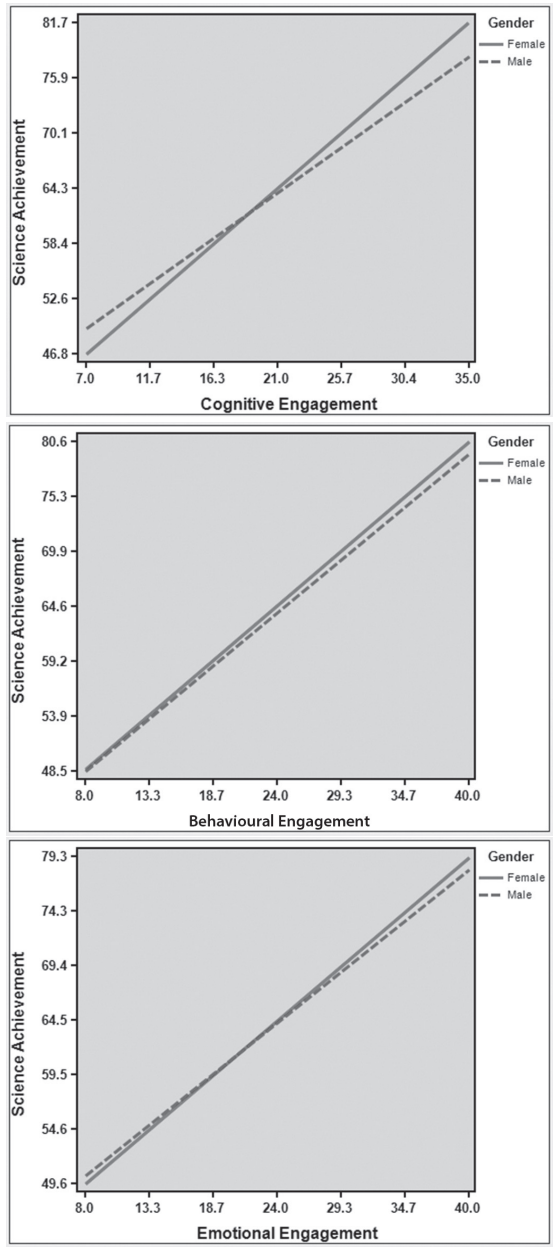
Results (see Table 3) shows that the overall moderation model was significant: R^2 = 0.824, F(3, 1228) = 2487.21, $p<0.001$. Further, the effect of cognitive (B = 3.65, 95 per cent CIs [1.64, 5.66]), behavioural (B = 1.87, 95 per cent CIs [1.06, 2.68]), and emotional engagement (B = 5.22, 95 per cent CI [3.57, 6.87]) on science achievement was positive and significant. Further, the interaction between cognitive engagement and gender (B = 0.21, 95 per cent CIs [0.12, 0.27]) and between emotional engagement and gender (B = 0.37, 95 per cent CIs [0.21, 0.53]) significantly influenced science achievement. However, the effect of interaction for behavioural engagement was found to be statistically not significant (B = 0.63, 95 per cent CIs [−0.16, 1.42]). Therefore, students' gender significantly moderated the association between student engagement dimensions (except behavioural sub-scale) and science achievement.

Table 3: Differential Effect of Gender on the Association between Student Engagement and Science Achievement

Regression path	B	SE	t	p	LLCI	ULCI
Predictor = cognitive engagement, Moderator = gender, outcome variable = science achievement						
R^2 = 0.824, F(3, 1228) = 2487.21, p<0.001						
Constant	4.27	0.53	8.12	<0.001	2.93	5.61
Cognitive engagement	3.65	0.47	7.69	<0.001	1.64	5.66
Gender	2.85	0.38	7.55	<0.001	1.07	4.63
Interaction effect: Cognitive engagement science achievement*	0.21	0.03	7.85	<0.001	0.12	0.27
Conditional effects						
Female group	0.85	0.01	58.35	<0.001	0.53	1.17
Male group	0.67	0.01	51.89	<0.001	0.38	0.96
Predictor = behavioural engagement, Moderator = gender, outcome variable = science achievement						
R^2 = 0.754, F(3, 1228) = 2965.27, p<0.001						
Constant	6.24	0.67	9.25	<0.001	4.16	8.32
Behavioural engagement	1.87	0.57	3.29	<0.01	1.06	2.68
Gender	4.28	0.65	6.59	<0.001	2.74	5.82
Interaction effect: Behavioural engagement science achievement*	0.63	0.72	0.87	0.857	-0.16	1.42
Predictor = emotional engagement, Moderator = gender, outcome variable = science achievement						
R^2 = 0.681, F(3, 1228) = 2865.3 , p<0.001						
Constant	6.12	0.83	7.34	<.001	4.04	8.20
Emotional engagement	5.22	0.75	6.98	<.001	3.57	6.87
Gender	5.62	0.96	5.87	<.001	3.78	7.46
Interaction effect: Emotional engagement science achievement*	0.37	0.05	7.56	<0.001	0.21	0.53
Conditional effects						
Female group	0.96	0.25	38.26	<0.001	0.73	1.19
Male group	0.81	0.24	33.54	<0.001	0.62	1.01

**Significant at 0.05 level*

Additionally, to know the trend of influence of the interaction between gender and three student engagement dimensions on science achievement, Graph 1 was plotted where no interaction was found for behavioural engagement. Besides, interactions of the plots for cognitive and emotional dimensions were found where the plots were steeper for the females indicating the relationships between the corresponding engagement dimensions and science achievement were stronger for girls than for boys. However, the relationship between behavioural engagement and science achievement did not depend upon students' gender. Thus, it can be said that how behavioural engagement influence achievement did not depend on the fact that a student is boy or girl. These findings provide conclusive evidences that gender gap in student engagement (except behavioural engagement) did not significantly contribute in explaining the gender difference in achievement.



Graph 1: The plots of effect of interaction between three engagement dimensions (i.e.; behavioural and emotional engagement) and gender on science achievement

Discussions

This study identified linkages between three student engagement dimensions and science achievement using a sample of secondary school students in West Bengal, India. The study firstly verified the three-dimensional measurement models of student engagement and further examined the two hypotheses.

Hypothesis 1 verified the relationships between three student engagement dimensions and science

achievement of students. The results show that emotional engagement is a better predictor of science achievement, than behavioural engagement, and cognitive engagement. Indeed, students' good emotional states are facilitated by their behaviours of continually and persistently engaging in learning activities (Skinner and Belmont, 1993). In addition, students' active involvement in learning activities increases their motivation to learn (Charles, Bustard and Black, 2009). Further, participation in school activities has been shown to affect students' performance in the classroom (Dalun et al., 2011; Roorda et al., 2011). However, there has been a lack of investigations on the effect of student engagement specifically on science achievement, considering all three engagement dimensions. To overcome the current lack of empirical evidence on how three student engagement dimensions influence science achievement of students, the current study provides concrete evidence on how enhancement in level of engagement in all three dimensions boost students' performance in science. Future studies may investigate the reasons behind these links.

Hypothesis 2 identified the differential effects of student engagement dimensions (except behavioural dimension) on science achievement of male and female students. Further, the relationship between student engagement dimensions (except behavioural dimension) and science achievement was found to be stronger for the girls. Thus, student engagement dimensions (except behavioural dimension) were found to be more beneficial for girls than for boys. However, behavioural engagement and science achievement was found to be related to the same extent for boys and girls. Thus, behavioural engagement was found to be equally important for girls and for boys. Early researches (for example, Halpern et al., 2007) reported that girls tend to score worse than males in maths and reading, while boys tend to perform better than girls in science. For example, Becker (1989), Steinkamp and Maehr (1984), and Halpern et al. (2007) found that boys do much better than girls in biology, basic science and physics, whereas females perform significantly better in language. Cleary (1991) discovered boys across different age groups surpassed girls in science. Males, according to a meta-analysis (Hedges and Nowell, 1995), do better in science classes and exams. Besides, several researches have demonstrated that girls exhibit lower academic self-concept, interest and motivation than boys do (Preckel et al., 2008). The literature cites a wide range of factors, each of which has a different impact on the academic outcomes that pupils acquire in various subjects. For example, Sirin (2005) noted that socio-economic status is one of the strongest predictors of student achievement, while Rivkin, Hanushek

and Kain (2005), and Swinton, Thomas, Benjamin, and Howard (2010) pointed out that teacher characteristics like educational and academic preparation as well as training and experience in teaching have a positive effect on student achievement.

Conclusions

It has been shown that there are noteworthy correlations between all three elements of student involvement and science achievement. The findings indicate that emotional component outperforms the behavioural and cognitive engagement as predictors of students' achievement in science (Roorda et al., 2011). In fact, students' consistent and continuous participation in learning activities contributes to their positive emotional states. Furthermore, pupils become more motivated to study when they actively participate in educational activities (Skinner and Belmont, 1993). Additionally, it has been shown that student performance in the classroom is impacted by involvement in school activities.

Further, the differential effects of student engagement components (apart from the behavioural dimension) on the science achievement of male and female students have been confirmed through the findings of this study. Additionally, it was shown that girls' cognitive and emotional engagement had stronger effects on their achievement in science (Preckel et al., 2008). It also emerged from the study that behavioural engagement was equally crucial for both boys' and girls' achievement in science.

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