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Original Article

Digital Meets Hands-on: Evaluating Blended Learning for Science Practical Experiments in High Schools of Cooch Behar

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Abstract

The research paper examines the impact of blended learning on the performance of students on the hands-on performance and theoretical learning in science practicals in Cooch Behar based high schools. Blended learning is a hybrid of classroom instruction and technology usage, and it is becoming more popular as an efficient method of enhancing theory and practical skills. The design took the form of a quantitative, correlational one. We gathered the data of 100 high-school students who had undergone the blended learning. Google Forms was used to send structured Likert-scale questionnaires to assess engagement, practical skills, and conceptual understanding. The data were analyzed using regression and correlation to determine the relationship between the variables. The regression analysis revealed that blended education had significant effects on the practical performance (R=0.327, p=0.001) and the conceptual understanding (R=0.401, p=0.000) and explained 10.7 percent and 16.1 percent of the variance, respectively. The correlation analysis revealed that there was a strong positive correlation between engagement and skill achievement (r 0.495, p 0.000), indicating that the greater the engagement, the greater the acquisition and application of skills. These results are all the evidence that blended learning does not only improve academic performance but also facilitates communication and engagement. The paper has found that incorporation of digital sources in the conventional laboratories will facilitate a more versatile, resourceful and interactive atmosphere that will enhance knowledge and applied expertise. Thus, blended learning can be a successful model of promoting science learning in high schools.

Keywords: *Blended Learning, Science Education, Practical Skills, Conceptual Understanding, Student Engagement, Digital Integration, High School Learning*

Introduction

Blended learning involves the integration of conventional and digital education methods. Students engage in a portion of their education within a traditional classroom setting, while the remainder occurs in an online environment. It offers learners the opportunity to participate in both teacher-led classroom instruction and online learning experiences. (Daskan & Yildiz, 2020), (McGarry, 2025), (Kaur, 2013)

Blended learning, the application of digital tools to practical activities, is effective in enhancing science practical skills and academic achievement of high-school students. Studies indicate that combating online resources and simulations with real-life experiments enhance the skills of students to interpret data, communicate findings, design experiments, and analyse the results. The approach also increases engagement, motivation and confidence resulting to high learning outcomes than just the traditional approaches. Blended learning provides a balance between the theory taught online and practical and hands-on work that enhances the science-process skills and understanding of science concepts among the students. (Hinampas et al., 2018), (Krishnan, 2025) Blended techniques led to significant improvement in practical skills such as the ability to interpret data, communicate the results, and design experiments and record observations. (A et al., 2024), (Hinampas et al., 2018)

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Students attending blended science practical's score better, are more active and would rather choose this approach in preference to the traditional teaching. (Hinampas et al., 2018), (Nuhoglu et al., 2024)

Lab rotations or actual experiments are used to supplement digital simulations, video tutorials, and online modules to enhance the understanding and store scientific information. (Nuhoglu et al., 2024), (Idris, 2022)

STEM programs that relate technical skills and collaboration to real-world situations encourage blended programs that foster technical skills and collaboration skills essential to contemporary science. (Oh, 2025)

Literature review

(Antonelli et al., 2023) The JANUS project financed by the EU designed a virtual reality (VR) robotics lab to continue holding student workshops during the pandemic. The VR laboratory enabled the students to repeat experiments in a variety of different angles providing them with safe and unrestricted exposure to lab settings. It was incorporated with the ViLLE platform of learning that facilitated self-evaluation and continuous assessment. There were two VR-based robotics workshops designed, giving the learners an opportunity to train in a simulated environment. The feedback indicated that students evaluated the blended learning positively, with better results and involvement, and the use of VR-based blended learning was worthwhile in technical educations.

(Sui & Yang, 2023) proposed an electronic engineering project-based blended learning model among students. The course Creative Innovation Practice involved online and offline components, experiments in the laboratory, and competitions according to the constructivist principles. This blend method enhanced self-directed learning and creativity and problem-solving in students. Through the Analytic Hierarchy Process (AHP), the authors concluded that blending learning increased motivation and enthusiasm and was effective in connecting the theoretical background to real-life engineering activities.

(Fleischmann, 2021) explored the possibility of designing a blended learning model based on design studio pedagogy. In the four-year and 119 students of undergraduate design, the study used a flipped classroom, a combination of online lectures, tutorials, as well as face-to-face practical studies. Students were to do projects, provide presentations and perform peer conversation to imitate real studio experiences. Both student and instructor feedback showed that this blended delivery format positively affected the learning outcomes, creativity and interaction and showed that design education can effectively integrate traditional and digital delivery methods.

(Ferr & Ferri, 2016) the course in rigid-body dynamics was redesigned to deliver 2D and 3D mechanics in a short time. They substituted the old lectures with MOOCs online, and actively engaged their learning and experimentation in the classroom. Pre-, post-, and longitudinal reviews provided good acceptability of the new method. Experiments conducted by students themselves were particularly appreciated by them and were seen as more interesting and useful compared to demonstrations conducted by the instructor. The analysis proved that experience-based, blended approaches increase student satisfaction and comprehension.

Objectives

- To examine the impact of blended learning on students' practical performance and conceptual understanding
- To analyze the relationship between students' engagement levels and their practical skill achievement within blended-learning environments.
- **Hypothesis**
- **H_{01} (Null Hypothesis):** Blended learning does not have a significant impact on students' practical performance and conceptual understanding.
- **H_{a1} (Alternative Hypothesis):** Blended learning has a significant positive impact on students' practical performance and conceptual understanding .
- **H_{02} (Null Hypothesis):** There is no significant relationship between students' engagement levels and their practical skill achievement in blended-learning environments.
- **H_{a2} (Alternative Hypothesis):** There is a significant positive relationship between students' engagement levels and their practical skill achievement in blended-learning environments

Research Methodology

Research Design

The research design applied in this study is the empirical quantitative design, which evaluates the impact of blended learning on performance of students in real science, their conceptual knowledge, and interest. The paper examines the correlation of four quantifiable variables, including the kind of learning model (blended learning), the degree of engagement, practical skills and theory. To find out the influence as well as the strength of correlation between these variables, a correlational, comparative design was selected. The design enables the researcher to test hypotheses in a statistically significant manner so as to establish whether blended learning has a significant positive impact in comparison to traditional instruction.

Sample Size

The research will involve 100 children who are in different high schools in Cooch Behar. The respondents include students in grades 9 and 10 who have had blended or tech-integrated lab activities. The sample of 100 will be enough to

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conduct the regression and correlation analysis and will have enough data to investigate the relationships and the impact of the blended learning on the results.

Data Collection

The Google Form survey was distributed to the students electronically through communication channels in the schools.

Data Analysis

The analysis is done using descriptive and inferential statistics. The correlation analysis was done on the relationship between engagement level and practical skill in blended environments. Regression was performed to determine the predictive effectiveness of blended learning on practical and conceptual performance. The evaluation of the results was conducted with a significance level of 0.05 in order to either accept or reject the null hypotheses. Analysis was done using Spss 22.0.

Result

Table: 1 Age of the respondents.

Age		
	Frequency	Percent
16	41	41.0
17	46	46.0
Above 17	13	13.0
Total	100	100.0

The above table discusses the frequency and percentage of age of the respondents. In 16 years age group, Frequency is 41 and percentage is 41.0%. In 17 years age group, Frequency is 46 and percentage is 46.0%. In above17 years age group, Frequency is 13 and percentage is 13.0%.

Graph: 1 Graphical representation of Age of the respondents.

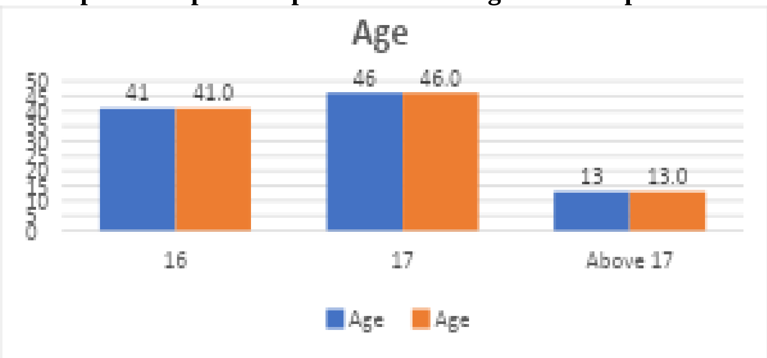

Table: 2 Gender of the respondents.

Gender		
	Frequency	Percent
Male	70	70.0
Female	30	30.0
Total	100	100.0

The above table discusses the frequency and percentage of gender of the respondents. In male group, Frequency is 70 and percentage is 70.0%. In female group, Frequency is 30 and percentage is 30.0%.

Graph: 2 Graphical representation of gender of the respondents.

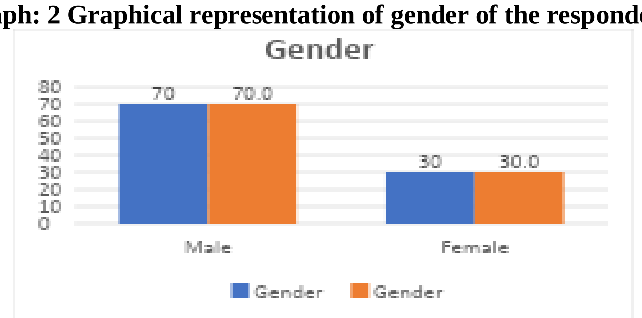

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Table: 3 Blended learning has a significant positive impact on students' practical performance.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.327[a]	.107	.098	.89823
a. Predictors: (Constant), Blended Learning				

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.492	1	9.492	11.765	.001[b]
	Residual	79.068	98	.807		
	Total	88.560	99			
a. Dependent Variable: Students' Practical Performance						
b. Predictors: (Constant), Blended Learning						

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.064	.537		3.845	.000
	Blended Learning	.410	.119	.327	3.430	.001
a. Dependent Variable: Students' Practical Performance.						

According to the regression analysis's findings, students' practical performance is significantly improved by blended learning. A moderately good association between blended learning and students' practical skills is suggested by the model summary's correlation coefficient (R) of 0.327. With a R Square value of 0.107, the mixed learning strategy can account for about 10.7% of the variation in students' practical performance. An F-value of 11.765 and a p-value of 0.001, which are significantly below the 0.05 cutoff, provide additional evidence of the model's importance in the ANOVA results. According to the coefficients table, students' practical performance rises by 0.410 units for every unit increase in the use of blended learning, with a positive unstandardized coefficient (B = 0.410) and a standardized Beta value of 0.327. More evidence of the strong positive effect is provided by the t-value of 3.430 at the significance level of 0.001.

Table: 4 Blended learning has a significant positive impact on students' conceptual understanding.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.401[a]	.161	.152	.77112
a. Predictors: (Constant), Blended Learning (Independent Variable)				

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.166	1	11.166	18.779	.000[b]
	Residual	58.274	98	.595		
	Total	69.440	99			
a. Dependent Variable: Conceptual Understanding						
b. Predictors: (Constant), Blended Learning						

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.191	.461		4.753	.000
	Blended Learning	.445	.103	.401	4.333	.000
a. Dependent Variable: Conceptual Understanding						

According to the regression analysis, students' conceptual understanding is significantly improved by integrated learning. A moderately good association between blended learning and conceptual understanding is suggested by the model summary's correlation coefficient (R) of 0.401. The use of blended learning can account for 16.1% of the diversity in students' conceptual comprehension, according to the R Square value of 0.161. The model's statistical significance is confirmed by the ANOVA table, which shows a strong predictive association with an F-value of 18.779 and a p-value of 0.000, both of which are significantly below the 0.05 level. The coefficients table also shows that blended learning has a positive unstandardized coefficient (B = 0.445) and a standardized Beta value of 0.401, which indicates that students' conceptual understanding increases by 0.445 units for every unit increase in the use of blended learning strategies. This conclusion is supported by the t-value of 4.333 at a significance level of 0.000.

Table: 5 There is a significant positive relationship between students' engagement levels and their practical skill achievement in blended-learning environments.

Correlations			
		Student Engagement Levels	Practical Skill Achievement
Student Engagement Levels	Pearson Correlation	1	.495**
	Sig. (2-tailed)		.000
	N	100	100
Practical Skill Achievement	Pearson Correlation	.495**	1
	Sig. (2-tailed)	.000	
	N	100	100
**. Correlation is significant at the 0.01 level (2-tailed).			

The correlation study demonstrates a statistically significant positive association between student involvement levels and practical skill achievement.

Discussion

This paper demonstrates that blended learning plays a major role in practical performance and conceptual learning in science among students. Regression analysis revealed that the blended learning predicts 10.7% of the variance of the practical performance and 16.1% of the conceptual understanding, which is statistically significant (p 2.05). Such findings imply that learners in a blended setting enjoy advantages of computing tools with practical exercises, which result in improved understanding and experimental capabilities. The positive beta values indicate that the greater the application of the blended learning, the greater are the achievements both in the conceptual and practical domains. The linear relationship between the student engagement and the practical skill achievement (r = 0.495) demonstrates that there is a strong correlation coefficient as a measure of positive relationship between digital interaction and performance in the experiment, indicating that student engagement mediates the relationship between digital interaction and performance in the experiment. More active students in the blended settings were more motivated, autonomous, and skilled in their use of skills in comparison to the students who used traditional teaching only. These results are in agreement with the previous research (Hinampas et al., 2018; Krishnan, 2025) that highlights the importance of blended learning in improving student-centered engagement and in-depth learning. By combining online simulations, virtual experiments and real-life laboratories, a dynamic environment is established which improves performance but also maintains the learners attention, which proves that blended learning can be an effective teaching method in science education.

Conclusion

The study has shown that blended learning has a great effect on enhancing practical performance and conceptual knowledge amongst students of science in high-school. Integration of digital tools and the use of traditional labs produces an interactive, adaptable, student-driven learning process. Regression studies verify the existence of the quantifiable positive effect of blended learning, whereas the correlation findings demonstrate that greater student engagement means greater practical results. These results disapprove the null hypotheses, and approve the alternative ones, thus proving that blended learning settings demonstrate significant academic efficacy as compared to traditional approaches. Blended learning is a viable approach to classroom science education in the future because the combination of virtual and physical learning stimulates curiosity, creativity, and collaboration. Comprehensively, this study supports that a well-designed blended learning not only provides a gap between theoretical and practical application of knowledge but also encourages students to take an active and self-directed role in the process of learning.

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