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EFFECT OF BLENDED LEARNING ON ACHIEVEMENT IN MATHEMATICS IN RELATION TO LEARNING STYLES AND INTELLIGENCE

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ABSTRACT

This study investigates the effect of blended learning on Grade IX students' mathematics achievement, considering their learning styles and intelligence levels. Using a 2×4×2 factorial design, students from two CBSE schools were grouped based on instructional strategy (blended vs. conventional), learning style—classified by Kolb's Learning Style Inventory (2007)—and intelligence level—measured by Ahuja's General Group Test of Intelligence (2005). Analysis via descriptive statistics, three-way ANOVA revealed that blended learning significantly enhanced math achievement. Students with higher intelligence scored better, while learning style alone had no significant main effect. However, interactions between instructional strategy and both learning style and intelligence were significant. No three-way interaction was observed. The findings highlight that blended learning boosts performance, with cognitive ability more influential than learning style.

Keywords : Blended learning, Mathematics Achievement, Kolb Learning Style Inventory, Ahuja General Group Test of Intelligence, Instructional Strategy, Learning Styles, Intelligence Levels

INTRODUCTION

The 21st century, characterized by globalization and fast-paced technological growth, has transformed education into a decisive tool for achievement. Mathematics, being the backbone of logical thought and problem-solving, assumes a crucial position in equipping students with appropriate abilities for further study and professional careers in science and technology. However, traditional teacher-based instruction tends to stress memorization and mechanical problem-solving, which compromise understanding, analytical abilities, and retention. This has led to extensive underachievement in mathematics and poor attitudes among students (Boaler, 2016; Freeman et al., 2014).

Blended learning, which is the integration of face-to-face instruction with online platforms, has proven to be a successful solution to these issues. It provides for interactive and adaptive learning spaces and places teachers in the role of facilitators instead of single knowledge-bearers (Garrison & Vaughan, 2008; Horn & Staker, 2014). Recent studies show its promise in improving mathematics achievement, conceptual understanding, and student motivation (Liu et al., 2022; Oktaviani et al., 2023; Tong et al., 2023). Nonetheless, a good deal of this evidence is drawn from the postsecondary level (Boelens et al., 2017), with scant investigation at the school level where mathematics learning deficiencies are of most concern.

Diversity among learners introduces yet another level of complexity. Personal variations in learning styles and intelligence influence how students respond to teaching methods and how well they can learn (Felder & Brent, 2005; Kolb, 2015). Though significant, the relationship between these variables and blended learning in mathematics education at the

secondary school level is still not adequately explored. Lacking this knowledge, the potential of blended learning as an inclusive pedagogy can remain unrealized.

The National Education Policy (NEP) 2020 necessitates incorporation of technology and new pedagogies to reinforce foundational competencies, especially mathematics, and to equip students with 21st-century skills (Government of India, 2020). This also offers both a policy call and a chance to explore blended learning at the school level in Indian settings.

Rationale of the Study

Though blended learning has gained international attention for enhancing engagement and achievement, evidence from secondary schooling—especially in mathematics—is limited. The majority of studies conducted thus far have been in higher education, where students are more independent and technologically savvy. Secondary school students, on the other hand, are different in terms of developmental needs, motivation, and cognitive preparedness, which questions whether blended learning impacts their mathematics achievement.

Moreover, mathematical achievement is also not determined solely by pedagogy but by learner-specific factors as well. Intelligence and learning styles have been said to affect students' processing and retention of information, but much is still left to be understood regarding the interaction of these with blended approaches under actual classroom conditions. It is paramount to fill this gap so that blended learning can positively impact a broad range of learners and not favor specific groups.

In accordance with NEP 2020's vision of inclusive, technology-enabled, and competency-based education, the present study investigates the impact of blended learning on mathematics achievement based on learning styles and intelligence among secondary school students. In doing so, it provides evidence for enhancing classroom practice and guiding the effective implementation of blended learning in school education. To investigate the effectiveness of blended learning on Mathematics achievement following objectives and hypotheses were developed.

Objectives of the Study

- To study the main effect of Instructional Strategies on Achievement in Mathematics of grade IX students.
- To study the main effect of different Learning Styles on Achievement in Mathematics of grade IX students.
- To study the main effect of high and low level of Intelligence on Achievement in Mathematics of grade IX students.
- To study interaction effect of Instruction Strategies and Learning Styles on Achievement in Mathematics of grade IX students.
- To study interaction effect of Instructional Strategies and Intelligence on Achievement in Mathematics of grade IX students.
- To study interaction effect of Learning Styles and Intelligence on Achievement in Mathematics of grade IX students.
- To study interaction effect of Instructional Strategies, Learning Styles, and Intelligence on Achievement in Mathematics of grade IX students

Hypotheses:

Ho_1: There will be no significant main effect of Instructional Strategies i.e., Blended Learning Instruction and Conventional mode of Instruction on Achievement of grade IX students in Mathematics.

Ho_2: There will be no significant main effect of different Learning Styles on Achievement of grade IX students in Mathematics.

Ho_3: There will be no significant main effect of high and low level of Intelligence on Achievement of grade IX students in Mathematics.

Ho_4: There will be no significant interaction effect of Instructional Strategies and Learning Styles on Achievement in Mathematics of grade IX students.

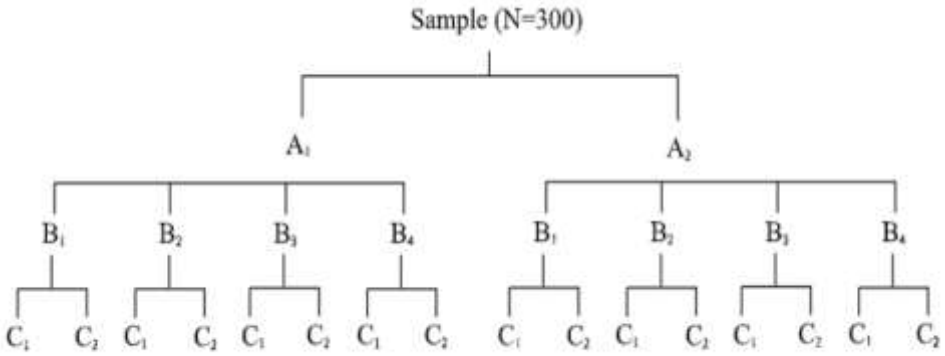
Ho_5: There will be no significant interaction effect of Instructional Strategies and Intelligence on Achievement of grade IX students in Mathematics.

Ho_6: There will be no significant interaction effect of Learning Styles and Intelligence on Achievement of grade IX students in Mathematics.

Ho_7: There will be no significant interaction effect of Instructional Strategies, Learning Styles and Intelligence on Achievement of grade IX students in Mathematics.

Design and Procedure

The present study, titled *"Effect of Blended Learning on Achievement in Mathematics in Relation to Learning Styles and Intelligence,"* was experimental in nature. A pre-test, post-test, 2X4X2 (three-way) factorial experimental design was used for the study.



Instructional strategy X Learning Style X Intelligence

The instructional strategy was the first factor, labelled as *Factor A*. It included two strategies: Blended learning Instruction (coded as A1) and Conventional mode of Instruction (coded as A2).

The second factor was *learning style*, coded as *Factor B*. Students were categorized into four distinct learning styles based on their scores from the Kolb Learning Style Inventory (Kolb, 2007). These styles were: B1: Diverging Style; B2: Converging Style; B3: Accommodating Style; B4: Assimilating Style

The third factor was *intelligence*, coded as *Factor C*. This factor had two levels: C1: High level of intelligence; C2: Low level of intelligence on the bases of General Group Test of Intelligence (GGTI) by G.C. Ahuja (2005). For the purposes of this study, students with an average level of intelligence were excluded by 27% Kelley ,1939.

Sample for the Study

In this study, the population consisted of all grade IX students in Punjab State. Sidana International School & Angels World Public School affiliated to CBSE were purposefully selected from the total population based on their ability to meet the prerequisites for the experiment. A final sample of 300 students of grade IX students was randomly drawn from these two schools.

Sample Distribution

Since this study involved two instructional strategies (blended learning and conventional mode), four learning styles (divergent, convergent, accommodating, and assimilating), and two levels of intelligence (high and low), the students (N=300) were distributed in three stages as described below:

Stage I: Sample Distribution Based on Instructional Strategies

The total sample of 300 students was randomly assigned into two groups using a flip of the coin. The groups were as follows:

- **Experimental Group** (N=150): Students taught using blended learning instruction.
- **Control Group** (N=150): Students taught using conventional instruction.

Stage II: Sample Distribution Based on Learning Style

After the groups were formed based on instructional strategy, both groups completed Kolb's Learning Style Inventory (2007). The students were categorized into one of four learning styles: Accommodating, Assimilating, Divergent, Convergent according to their scores on the inventory.

Table 1: Distribution of students in each learning style within each group

Learning Styles	No of students in Experimental Group	No of students in Control Group
Accommodating style	39	42
Assimilating style	40	37
Converging style	37	38
Diverging style	34	33

Stage III: Sample Distribution Based on Intelligence

Students' intelligence was assessed using the GGTI (Ahuja, 2005). The intelligence scores were ranked in descending order, and students were categorized (Kelley, 1939) as follows:

- High Intelligence (HI): Top 27%
- Low Intelligence (LI): Bottom 27%
- Students with average intelligence were excluded.

Table 2: The distribution of HI and LI students across learning styles is summarized below:

Group	Learning Style	HI	LI
Experimental (N=82)	Diverging	9	9
	Converging	10	10

Group	Learning Style	HI	LI
	Assimilating	11	11
	Accommodating	11	11
Control (N=80)	Diverging	9	9
	Converging	10	10
	Assimilating	10	10
	Accommodating	11	11

Only HI and LI students were included in further analysis.

Procedure

Following the classification of the sample based on learning styles and intelligence levels, the study involved 162 students, with 82 assigned to the experimental group and 80 to the control group. Mathematics Achievement test prepared by the investigator was employed to test the achievement of the sample at pre-test stage. Two instructional strategies were employed: the experimental group received instruction via blended learning approach, while the control group was taught using the conventional teaching method. Mathematics topics for Grade IX, as outlined by the NCERT curriculum, were uniformly delivered to both groups over a 40-day instructional period. Lesson Plans were developed by the investigator from the selected topics of mathematics for grade IX, based on the NCERT curriculum.

Content delivery for the blended learning group incorporated multiple modalities, including 3D-shape models, PowerPoint presentations, expert lectures conducted through video conferencing, and relevant instructional videos. Additionally, Google Classroom was utilized as a Learning Management System (LMS) to facilitate interactive, two-way communication i.e. submission of assignments, getting links of online videos and quiz related to the content. In addition to that control group was also taught by the investigator in both the schools. Techniques to teach the content in conventional strategy was the lecture method, use of teaching aids as black board, working models, demonstration etc. lesson plans Upon completion of the instructional program, a mathematics achievement test according to the content taken for study, prepared by the investigator was administered to both groups as a post-test to assess learning outcomes.

Statistical Techniques

The data analysis involved the following statistical methods: Descriptive statistics (mean, median, mode, standard deviation, skewness, kurtosis) were used to summarize data characteristics. A three-way (2×4×2) ANOVA was conducted on the sample (N=162) to assess the main and interaction effects of instructional strategy, learning style, and intelligence on mathematics achievement. Where significant F-values were found to evaluate mean differences between groups.

Table 3: Discussion of Results

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Main Effect					
Instructional Strategy (A)	2411.701	1	2411.701	113.121	.000

Learning Style (B)	73.609	3	24.536	1.151	0.331
Intelligence (C)	484.223	1	484.223	22.712	.000
First Order Interaction					
Instructional Strategy X Learning Style (AXB)	33.625	3	11.208	0.526	0.665
Instructional Strategy X Intelligence (AXC)	185.223	1	185.223	8.688	.004
Learning Style X Intelligence (B X C)	34.000	3	11.333	0.526	0.661
Second Order Interaction					
Instructional Strategy X Learning Style X Intelligence (AXBXC)	9.062	3	3.021	0.142	0.935
Within Group (Error)	3112.676	146	21.320		
Total	77473.000	162			

Main Effect of Instructional Strategies (A)

The F-ratio for Instructional Strategies was found to be highly significant ($F = 113.121$, $p < .01$)**.** This finding led to the rejection of **Ho_1**, which postulated no significant difference in achievement between students taught through blended learning and those taught through the conventional method. The mean gain scores revealed that students in the experimental group (blended learning) performed significantly better than those in the control group (conventional teaching). This highlights the superiority of blended learning in enhancing mathematical achievement at the secondary level. The observed improvement may be attributed to the integration of digital resources, interactive content, and face-to-face instruction in blended learning, which seems to maximize student engagement and understanding. Result is supported by mean gain scores too.

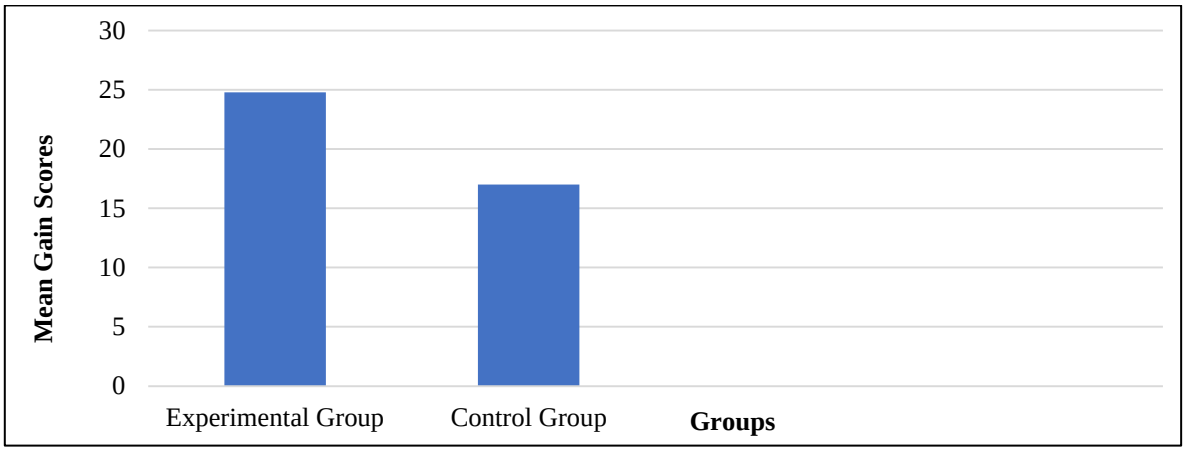


Figure1: Mean Gain Scores of Experimental Group and Control Group on Achievement Test

Main Effect of Learning Styles (B)

The F-ratio for the main effect of Learning Styles was found to be insignificant ($F = 1.151$, $p > .05$)**.** Consequently, **Ho_2** was accepted, confirming that achievement in mathematics did not vary significantly with respect to students' learning styles. The negligible differences among the mean gain scores of students with different learning styles further support this finding.

This implies that learning styles may not have a dominant role in determining academic achievement in mathematics when effective instructional methods, such as blended learning, are in place. It suggests that blended learning may provide sufficiently diverse instructional inputs to cater to multiple learning styles simultaneously, thereby minimizing their differential effects.

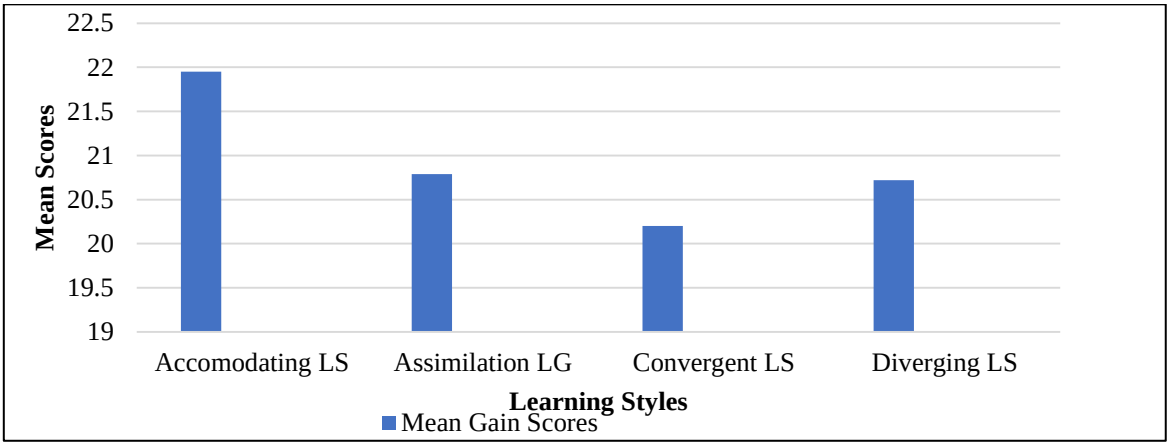


Figure 2: Mean Gain Scores of Total Sample in Achievement Test of Mathematics w.r.t., Learning Styles.

The difference between mean gain scores of four learning styles is very less which supports the F* value leads to acceptance of Ho2. The result revealed that there exists no significant difference in mean gain scores in achievement of mathematics with respect to different learning styles.

Main Effect of Intelligence (C)

The main effect of Intelligence was found to be significant ($F = 22.712$, $p < .01$)**,** leading to the rejection of **Ho_3**. The results indicated that students with high levels of intelligence outperformed those with low levels of intelligence in mathematics achievement. This outcome aligns with widely established findings in educational psychology that intelligence is a key predictor of academic success. The significant mean score differences between high- and low-intelligence groups reinforce the role of cognitive ability as a determinant of performance in mathematics, a subject requiring conceptual reasoning and logical thinking.

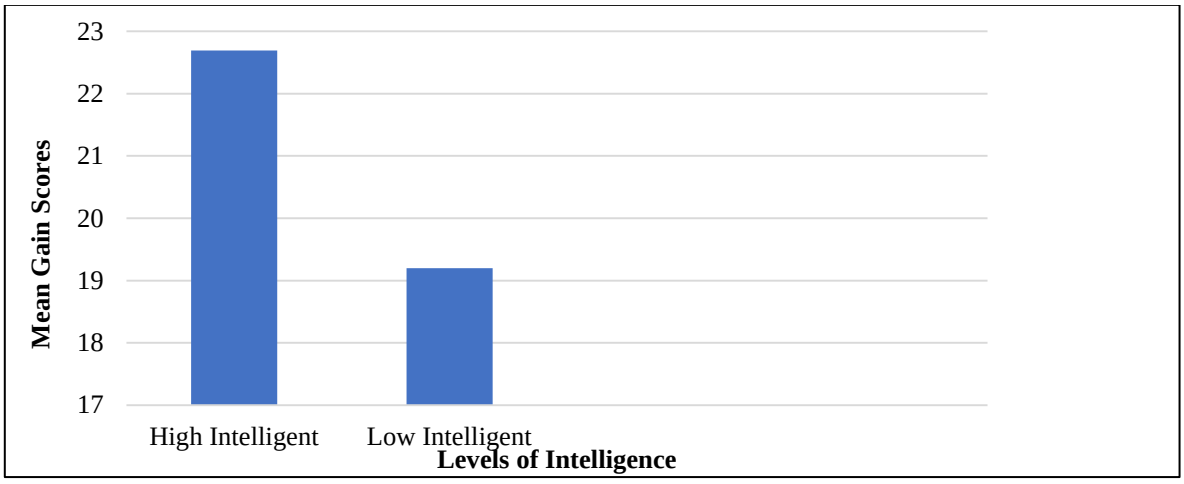


Figure 3: Mean Gain Scores of Total Sample in Achievement Test of Mathematics w.r.t., Intelligence.

The difference came out to be significant in mean gain scores in achievement of mathematics with high level of intelligence and low level of intelligence. Hence, Ho_3 stands rejected which was further supported by mean gain scores of high intelligent and low intelligent students in achievement test which were found to be significantly different.

First Order Interaction Effects

Interactional Effect of Instructional Strategies and Learning Style (A X B)

The interaction between instructional strategies and learning styles was found to be insignificant ($F = 0.526$, $p > .05$)**,** which supports acceptance of the null hypothesis Ho_4. This indicates that the effectiveness of blended learning or conventional teaching is not significantly influenced by students' learning style preferences. Thus, blended learning proved equally beneficial regardless of preferred style.

Interactional Effect of Instructional Strategies and Intelligence (A X C)

The interaction between instructional strategies and intelligence level was significant ($F = 8.688$, $p < .01$), leading to the rejection of the null hypothesis Ho_5. Further t-test analysis showed that both high-intelligence and low-intelligence students benefited more from blended learning compared to conventional teaching. However, the positive impact of blended learning was more pronounced among low-intelligence students, suggesting that blended approaches may compensate for lower cognitive ability by providing scaffolding, multimedia support, and self-paced learning opportunities**.**

Interactional Effect of Learning Styles and Intelligence (BXC)

The interaction between learning styles and intelligence was **insignificant ($F = 0.526$, $p > .05$)**. F- ratio for the interaction between four learning styles and two levels of intelligence is insignificant, leads to the acceptance of null hypothesis Ho_6. Thus, no combined effect of these two variables on mathematics achievement was found. This suggests that regardless of intelligence level, learning style does not differentially affect achievement outcomes.

Second Order Interaction Effect

Interactional Effect of Instructional Strategy, Learning Styles and Intelligence (AXBXC)

The three-way interaction among instructional strategies, learning styles, and intelligence was found to be insignificant ($F = 0.142$, $p > .05$) leads to acceptance of null hypothesis Ho7. This reveals that the combined interplay of these three variables does not have any significant influence on achievement beyond their individual and first-order interactions.

Summary of the Results

- Blended learning enhanced student achievement in mathematics significantly more than conventional teaching.
- Intelligence exerted a strong main effect on achievement, with high-intelligence students outperforming low-intelligence peers.
- Learning styles had no significant effect on mathematics achievement under the studied conditions.
- Blended learning proved effective across intelligence levels, and particularly provided added benefits to lower-intelligence students.

- No significant higher-order interactions were observed among learning styles and intelligence with instructional methods.

Educational Implications

The findings carry important implications for classroom practice:

- **Adopting blended learning:** Blended learning should be encouraged in secondary mathematics classrooms, as it significantly enhances achievement outcomes.
- **Supporting diverse learners:** Since blended learning was effective for both high- and low-intelligence students, it can serve as an inclusive strategy to reduce performance gaps.
- **Rethinking learning styles:** Teachers need not overemphasize tailoring instruction to fixed learning styles; rather, adopting blended learning frameworks may naturally accommodate diverse preferences.
- **Policy and curriculum integration:** Educational policymakers should integrate blended learning models into curricula and provide training to teachers for effective use.

CONCLUSION:

The study revealed that blended learning significantly enhances mathematics achievement compared to conventional teaching and is effective across different learning styles and intelligence levels. While learning styles had no notable impact, intelligence influenced achievement, with high-intelligence students performing better, though low-intelligence students showed greater gains under blended learning**,** highlighting its inclusive nature. Blended learning, by combining digital resources with face-to-face interaction, offers a flexible, student-centered approach that engages learners, supports diverse needs, and fosters better outcomes. With teachers playing a key role in guiding, motivating, and supporting students, the approach holds strong potential to create an inclusive and effective learning environment where all learners, regardless of their intelligence or learning styles, can thrive**.**

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