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Factor-Based Evaluation of Blended Learning Practices and Effectiveness in CBSE Secondary Schools of Ranchi

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ABSTRACT: Blended learning combines face-to-face instruction with digital platforms, multimedia resources, online assignments, assessment, and communication. This article develops a comprehensive framework for examining its approaches, challenges, and perceived effectiveness in CBSE secondary schools of Ranchi. It synthesises prior scholarship and converts three stakeholder questionnaires for students, teachers, and administrators into a testable measurement model. The common instrument contains constructs relating to blended-learning approaches, teacher preparedness, infrastructural and technological challenges, perceived effectiveness, and improvement priorities. Teacher and administrator forms additionally assess pedagogical effectiveness, whereas the student form includes engagement and learning outcomes. A factor-extraction plan using exploratory factor analysis, parallel analysis, oblique rotation, reliability assessment, and confirmatory factor analysis is proposed. The framework also recommends separate stakeholder analyses and a common-core multi-group comparison to prevent inappropriate pooling of non-equivalent items. The article identifies internet connectivity, device access, technical support, teacher competence, instructional planning, student participation, and institutional support as central implementation conditions. It offers a rigorous basis for subsequent empirical testing and for practical decisions by schools, teachers, administrators, and policymakers.

KEYWORDS: blended learning; CBSE secondary schools; factor extraction; exploratory factor analysis; teacher preparedness; student engagement; Ranchi

I. INTRODUCTION

Blended learning has become an important educational approach because it deliberately integrates classroom interaction with online and digital learning. In secondary education, it may include smart classrooms, learning management systems, educational applications, multimedia presentations, recorded lessons, virtual discussions, online assignments, digital feedback, and computer-supported assessment. The central idea is not simply to add technology to teaching, but to organise face-to-face and digital experiences so that each mode performs the function for which it is most suitable.

CBSE schools increasingly use technology to support innovative pedagogy, continuity of learning, access to resources, and learner-centred instruction. In Ranchi, however, schools operate under varied institutional and socio-economic conditions. Differences in connectivity, devices, technical infrastructure, teacher training, family support, and student digital literacy may produce unequal blended-learning experiences. A local study must therefore examine both the practices adopted and the conditions that enable or constrain them (*Duggal et al., 2021; Ghosh, 2020*).

Earlier studies generally report that blended learning can strengthen achievement, conceptual understanding, communication, creativity, motivation, flexibility, and self-directed learning. Yet positive outcomes are not automatic. Poorly planned online work may increase workload, reduce attention, or reproduce traditional teaching through a digital medium. The quality of blended learning depends on purposeful instructional design, prepared teachers, engaged students, reliable infrastructure, responsive assessment, and institutional support.

Blended learning is a planned combination of direct classroom teaching and technology-mediated learning. Face-to-face instruction supports immediate explanation, social interaction, classroom discussion, and teacher guidance. Digital environments provide flexibility, repeat access to content, self-paced practice, multimedia representation, rapid feedback, and learning beyond school hours. When aligned with curricular objectives, the model can accommodate differences in pace and ability and can support differentiated and personalised instruction (*Choudhary, 2026*).

At the secondary level, blended learning also develops digital literacy, self-regulation, independent study, collaboration, and problem-solving. These competencies are relevant to higher education and future employment. Teachers can use learning data to identify misconceptions, provide targeted feedback, and vary instructional resources. The educational value of technology depends on pedagogy; the platform itself cannot substitute for clear objectives, meaningful tasks, interaction, and assessment (*Jaswal & Behera, 2026*).

Table 1. Principal Blended-Learning Approaches

Approach	Application in Secondary Schools
Rotation approach	Students alternate between teacher-led lessons, digital tasks, collaborative work, and independent practice.
Flipped classroom	Students study videos or readings before class and use classroom time for discussion, application, and problem-solving.
Flex approach	Digital learning forms the main pathway while teachers provide individual or small-group support.
Enriched virtual approach	Most content is completed online with scheduled face-to-face sessions for guidance, laboratory work, or assessment.
Project-based blend	Classroom collaboration is combined with online research, shared documents, multimedia production, and digital presentation.
Assessment-supported blend	Online quizzes and analytics provide feedback that informs subsequent classroom teaching and remediation.

II. RESEARCH BACKGROUND

The reviewed studies collectively showed that blended learning had emerged as an effective instructional approach for improving academic achievement, communication skills, creativity, conceptual understanding, learner motivation, and engagement among school students. Several studies had reported that combining face-to-face teaching with digital tools and ICT-based resources produced better learning outcomes than conventional classroom teaching alone. At the same time, research had highlighted the growing importance of online learning, artificial intelligence, virtual classrooms, and digital education in making learning more flexible, accessible, personalized, and learner-centered.

Table 2. Findings from Literature Study

Author(s) & Year	Focus of the Study	Methodology	Major Findings
Jaswal and Behera (2026)	Effectiveness of blended learning in improving communication skills among secondary students	29 students; partly mixed sequential dominant status design; field notes, focus groups, learning logs and communication skills scale	Blended learning significantly improved communication skills such as listening, writing, online sharing, responding, supporting others and interaction.
Pujar (2026)	Effectiveness of blended learning on Biology achievement	80 Grade IX students from a CBSE-affiliated school; quasi-experimental pre-test-post-test control group design	Blended learning significantly improved conceptual understanding and academic achievement in Biology.
Misra et al. (2026)	Role of digital education and emerging technologies in teaching and learning	Conceptual/review-based study	Digital education improved accessibility, flexibility and personalized learning, but teacher training and equitable technological access remained important.
Choudhary (2026)	Effect of blended learning strategies on creativity among primary students	200 students from two CBSE-affiliated schools; experimental method	Students taught through blended learning obtained higher creativity scores than those taught through traditional methods.
Shankar et al. (2025)	Integration of Generative AI in STEM education	67 digitally literate Indian high-school teachers; purposive sampling, open-ended questionnaires and	Generative AI supported personalised, inclusive and interactive learning, though infrastructure and digital literacy affected adoption.

		SWOT analysis	
Moin and Patteti (2025)	Impact of blended learning on ninth-grade Urdu achievement	True experimental pre-test-post-test design; control and experimental groups	Blended learning significantly improved academic achievement; parental education, family income and medium of instruction also influenced performance.
Zahedi and Hussain (2025)	Development and effectiveness of ESL teaching in West Bengal	Mixed-methods; curriculum analysis, teacher surveys, student interviews and classroom observations	Teacher training, instructional resources and curriculum implementation were important factors affecting ESL effectiveness.
Kumari and Murthy (2024)	Comparison of blended and traditional learning in secondary education	Post-test experimental approach using academic records	Blended learning positively influenced academic achievement and could improve teacher effectiveness and student learning outcomes.
Pappu and Sayed (2024)	Education policies during COVID-19 in India and South Africa	Policy review and comparative analysis	Pandemic policies often affected disadvantaged groups disproportionately; future policies should safeguard both educational equity and quality.
Maryam and Lodi (2023)	Effectiveness of traditional and online science teaching	60 eighth-grade students; control and experimental groups; pre-test and post-test	No significant difference was found between online and traditional teaching; both were equally effective in improving academic performance.
Karmakar (2023)	Self-directed blended learning after COVID-19	224 students from four Kendriya Vidyalayas in Assam; questionnaires, checklists, academic records and SPSS	Physical, social and intellectual factors influenced blended learning, while blended learning showed a positive relationship with academic achievement.
Mondal et al. (2023)	NEP 2020 and the significance of digital and online education	Policy-oriented analytical study	NEP 2020 strengthened the role of digital platforms, online courses and alternative teaching approaches for continuity and flexibility in education.
Lakshman et al. (2022)	Impact of COVID-19 on education in Bangalore	Review of pandemic-related educational changes and government measures	The pandemic disrupted traditional education but accelerated the adoption of digital platforms and technology-based teaching.
Tyagi and Pal (2022)	Relationship between academic achievement and problem-solving ability	500 Class 10 students from CBSE-affiliated and National Open Schools; descriptive survey	A positive and moderate relationship existed between academic achievement and problem-solving ability, with significant differences between regular and open modes.
Kumar and Haldwani (2021)	Digital learning during COVID-19	Review of ICT tools, virtual learning and government initiatives	The pandemic accelerated the adoption of ICT, virtual classrooms and hybrid models, while revealing benefits and limitations of digital education.
Raviya and Upadhyay (2021)	Shift from traditional classrooms to ICT-supported learning	Review of ICT development and COVID-19-related changes in India	Technology made education more flexible, accessible and learner-centred and supported continuity during lockdowns.
Panigrahi and Dwivedi (2021)	Impact of COVID-19 and government measures for online learning	Analytical review of digital and distance learning	Internet connectivity, devices, affordability, technological skills and infrastructure were major requirements and challenges for effective online education.
Duggal et al. (2021)	Online education in India during COVID-19	Review of published and unpublished literature	Unequal internet access, weak infrastructure, limited resources, institutional unpreparedness and insufficient teacher training were major barriers to online and hybrid learning.
Mehar and Jassar	Effect of blended learning on Economics	120 Class XI students from two CBSE-affiliated private	Blended learning produced significantly higher academic achievement than

(2020)	achievement and motivation	schools; experimental design	traditional teaching, and motivation also positively influenced performance.
Ghosh (2020)	COVID-19 disruption and digital transformation of Indian education	Analytical article/review	The pandemic accelerated e-learning, virtual classrooms, homeschooling and blended learning while creating academic and psychological challenges for students.

Research conducted during and after the COVID-19 period further shows that educational systems adopted online and hybrid modes rapidly, often without equal access or sufficient preparation. Digital platforms-maintained continuity but exposed differences in internet access, devices, institutional capacity, teacher training, and home support. Policy discussions connected with NEP 2020 similarly emphasise digital resources and flexible learning, while recognising the need for equity, teacher development, and quality assurance (*Kumar & Haldwani, 2021*).

Table III. Thematic Synthesis of the Reviewed Studies

Theme	Main Variables	Illustrative Sources
Learning outcomes	Achievement, conceptual understanding, communication, creativity, problem-solving	Jaswal & Behera, 2026; Pujar, 2026; Choudhary, 2026; Mehar & Jassar, 2020
Learner processes	Motivation, self-direction, flexibility, interaction, personalised learning	Karmakar, 2023; Misra et al., 2026
Teacher capacity	Digital competence, instructional design, assessment, professional development	Shankar et al., 2025; Zahedi & Hussain, 2025
Infrastructure and equity	Connectivity, devices, affordability, technical support, unequal access	Duggal et al., 2021; Panigrahi & Dwivedi, 2021; Pappu & Sayed, 2024
Policy and system change	Digital initiatives, hybrid models, institutional readiness, continuity	Mondal et al., 2023; Kumar & Haldwani, 2021; Ghosh, 2020

Existing research has often examined a single subject, a limited student group, or emergency online learning. Fewer studies jointly consider the views of students, teachers, and administrators in CBSE secondary schools within Ranchi. There is also a need to distinguish between the mere presence of technology and the quality of its pedagogical integration. A locally validated factor structure is therefore required before relationships among blended-learning practices, challenges, engagement, and outcomes are interpreted.

- To identify the blended-learning approaches used in CBSE secondary schools of Ranchi.
- To assess teacher preparedness and pedagogical effectiveness in blended environments.
- To examine infrastructural and technological challenges affecting implementation.
- To analyse student engagement, learning outcomes, and perceived effectiveness.
- To extract and validate the underlying factors represented in the stakeholder questionnaires.
- To suggest practical measures for improving equitable and effective blended learning.

The principal research questions are:

- Which blended-learning practices are used most frequently?
- What infrastructure and preparedness conditions influence implementation?
- Which latent factors are supported by the questionnaire responses?
- How do students, teachers, and administrators differ on common constructs?
- To what extent do preparedness, infrastructure, and pedagogical effectiveness explain engagement, learning outcomes, and overall perceived effectiveness?

III. PROPOSED FACTOR-EXTRACTION FRAMEWORK

A cross-sectional descriptive and explanatory survey design is appropriate. The target population comprises Class IX-X students, teachers, and academic administrators of government and private CBSE secondary schools in urban and rural areas of Ranchi. A multistage stratified sampling procedure should first select schools by location and management type and then select participants within each school. The final sample should be large enough for stable factor analysis.

As a practical rule, at least 5-10 responses per analysed item and preferably 200 or more cases per stakeholder model should be sought. Where feasible, separate subsamples should be used for exploratory and confirmatory analyses.

Three questionnaires are used for student, teacher, and administrator forms. All closed statements employ a five-point scale from 1 (strongly disagree) to 5 (strongly agree), followed by open-ended questions about useful practices, major difficulties, and suggestions. Demographic variables include gender, school location, school type, class or experience, subject taught, and administrative designation. Expert review should examine relevance, clarity, age appropriateness, and stakeholder suitability before field administration.

The questionnaire sections provide a theory-guided starting structure, but the empirical factor pattern must be established from actual responses. The factor extraction should therefore be reported as a validation process rather than as a predetermined result. Items should be coded consistently, screened for missing data and response patterns, and analysed separately for each stakeholder group before any combined comparison.

Table IV. Proposed Constructs and Questionnaire Item Mapping

Code	Construct	Items	Respondents	Measurement Note
BLA	Blended-Learning Approaches	1-5	Student, teacher, administrator	Reflective
TP	Teacher Preparedness	6-10	Student, teacher, administrator	Reflective
ITC	Infrastructure and Technology Challenges	11-15	Student, teacher, administrator	Reflective; higher scores = greater challenge
PE	Pedagogical Effectiveness	16-20	Teacher and administrator	Reflective
SE	Student Engagement	21-26	Student only	Reflective
SLO	Student Learning Outcomes	27-31	Student only	Reflective
PEBL	Perceived Effectiveness of Blended Learning	32-36	All groups	Reflective
RFI	Recommendations for Improvement	37-42	All groups	Prefer descriptive priority index; test factorability separately

Before extraction, frequencies, missing values, means, standard deviations, skewness, kurtosis, floor or ceiling effects, and inter-item correlations should be examined. Items with near-zero variance or extensive missingness require review. Because the response scale is ordinal, a polychoric correlation matrix is preferable when software permits. Bartlett's test should be significant and the Kaiser-Meyer-Olkin measure should ordinarily be at least .60, with higher values indicating stronger common variance.

Principal axis factoring or minimum residual extraction is recommended because the purpose is to identify latent constructs, not merely reduce data. The number of factors should be decided through parallel analysis and inspection of the scree plot, supported by theoretical interpretability. Since educational constructs are likely to correlate, an oblique rotation such as Promax or Direct Oblimin should be used. Principal component analysis may be reported only as a supplementary reduction procedure and should not replace common-factor analysis.

Table V. Recommended Factor-Retention and Item-Quality Criteria

Criterion	Recommended Decision Rule	Purpose
Sampling adequacy	Overall KMO $\geq$.60; inspect item-level MSA	Supports meaningful common variance
Correlation matrix	Bartlett's test $p < .05$	Rejects an identity matrix
Factor retention	Parallel analysis + scree plot + theory	Avoids over-reliance on eigenvalue > 1
Primary loading	Preferably $\geq$.50; minimum .40	Shows substantive association with a factor

Criterion	Recommended Decision Rule	Purpose
Communality	Preferably $\geq .40$; review items below .30	Shows variance explained by common factors
Cross-loading	Difference between two loadings $\geq .20$	Supports simple and interpretable structure
Factor definition	At least three coherent items	Improves stability and content coverage
Reliability	Alpha and omega $\geq .70$	Assesses internal consistency

The student instrument should initially test BLA, TP, ITC, SE, SLO, PEBL, and—if treated as a scale—RFI. The teacher and administrator instruments should test BLA, TP, ITC, PE, PEBL, and RFI. Items 21-31 are absent from the teacher and administrator forms, while items 16-20 represent a different respondent perspective. Therefore, all 42 items must not be pooled across stakeholder groups as though they were identical.

A common-core comparison can use items 1-15 and 32-36 because these items appear across all three instruments. Before comparing latent means, configural, metric, and scalar measurement invariance should be tested. If full invariance is not achieved, partial invariance may be considered only when theoretically justified. The recommendation items 37-42 express desired interventions rather than a single psychological trait; they may be more informative as item-wise priorities or as an index after separate evidence of unidimensionality.

After EFA, retained scales should be evaluated using Cronbach's alpha and preferably McDonald's omega. Corrected item-total correlations should generally exceed .30. Confirmatory factor analysis should then test the proposed measurement model. Model fit may be evaluated using chi-square divided by degrees of freedom, CFI, TLI, RMSEA, and SRMR. Values of CFI and TLI near or above .90, RMSEA below .08, and SRMR below .08 generally indicate acceptable fit, but all indices, residuals, theory, and sample size should be considered together. Composite reliability above .70 and average variance extracted near or above .50 support convergent validity. Discriminant validity may be examined with the HTMT ratio and comparison of inter-construct relationships.

Table VI. Factor-Analysis Results (Expected)

Item Set	Expected Factor	Pattern Loading	Communality	Decision
BLA1-BLA5	BLA	[loading]	[h ²]	Retain/delete with reason
TP1-TP5	TP	[loading]	[h ²]	Retain/delete with reason
ITC1-ITC5	ITC	[loading]	[h ²]	Retain/delete with reason
PE1-PE5	PE	[loading]	[h ²]	Teacher/administrator model
SE1-SE6	SE	[loading]	[h ²]	Student model
SLO1-SLO5	SLO	[loading]	[h ²]	Student model
PEBL1-PEBL5	PEBL	[loading]	[h ²]	Common-core model

Important reporting note: the bracketed values in Table 5 are intentionally left as placeholders. They must be replaced only after analysing the completed survey dataset. Reporting assumed loadings, KMO values, explained variance, or reliability coefficients would misrepresent empirical evidence.

The validated factors can be organised into an explanatory model. Blended-learning approaches represent the degree of planned integration; teacher preparedness, infrastructure, and pedagogical effectiveness represent enabling or constraining conditions; student engagement and learning outcomes represent proximal outcomes; and perceived effectiveness represents the overall evaluative outcome. School type and location may be included as contextual controls or grouping variables.

Table VII. Proposed Hypotheses

Hypothesis	Statement
H01	Blended-learning approaches do not significantly influence perceived effectiveness.
H02	Teacher preparedness does not significantly influence pedagogical effectiveness.
H03	Infrastructure and technology challenges do not significantly influence perceived effectiveness.
H04	Pedagogical effectiveness does not significantly influence perceived effectiveness.
H05	Student engagement does not significantly influence student learning outcomes.
H06	Student learning outcomes do not significantly influence perceived effectiveness.
H07	There is no significant difference in common-core factor scores across students, teachers, and administrators.
H08	There is no significant difference in factor scores by school type or school location.

Table VIII. Statistical Analysis Plan

Purpose	Technique	Application
Respondent profile	Frequency and percentage	Gender, location, school type, class/experience, subject/designation
Item description	Mean, SD, median, response percentage	All Likert items
Measurement discovery	EFA with parallel analysis and oblique rotation	Separate stakeholder datasets
Reliability	Alpha, omega, corrected item-total correlation	Each retained factor
Measurement confirmation	CFA, CR, AVE, HTMT	Separate and common-core models
Group comparisons	t test, ANOVA/MANOVA or robust alternatives	School type, location, stakeholder group
Explanatory relationships	Multiple regression or SEM	Preparedness/challenges effectiveness/outcomes ->
Open responses	Thematic coding and illustrative quotations	Practices, challenges, recommendations

The integrated framework suggests that successful blended learning is a system-level outcome. A school may possess devices yet obtain weak results when teachers lack instructional support, online tasks are disconnected from classroom objectives, or students cannot sustain participation. Conversely, a resource-constrained school may still improve learning when it uses accessible platforms, carefully sequences online and classroom tasks, provides offline alternatives, and offers timely teacher feedback.

Teacher preparedness is possible to connect infrastructure with classroom practice. Digital skill alone is insufficient; teachers need competence in lesson design, online interaction, assessment, feedback, workload management, and student protection. Pedagogical effectiveness should therefore be measured separately from general confidence with

technology. This distinction is built into the teacher and administrator questionnaires through items on classroom management, assessment, monitoring, balance of responsibilities, and attention during online sessions.

From the student perspective, engagement and learning outcomes are related but distinct. Participation, interest, timely completion, interaction, independent learning, and attendance describe behavioural and motivational engagement. Improved performance, conceptual understanding, retention, problem-solving, and examination preparation represent perceived outcomes. Factor analysis can test whether respondents distinguish these domains and whether engagement acts as a pathway between blended-learning practices and learning outcomes.

Infrastructure and technological challenges should be interpreted as more than technical inconvenience. Connectivity failure, limited devices, weak ICT facilities, and insufficient support can reduce instructional time, participation, fairness, and trust in the system. Their effects may be stronger in rural settings or among households with fewer resources. Reporting differences by school location and management type is therefore necessary for equity-sensitive recommendations.

Table IX. Action-Oriented Recommendations

Area	Recommended Action
Infrastructure	Provide stable connectivity, adequate devices, power backup, secure platforms, and responsive technical support.
Teacher development	Offer continuing, practice-based training in blended lesson design, assessment, engagement, accessibility, and digital safety.
Instructional planning	Align every digital activity with curriculum outcomes and integrate it with preceding and subsequent classroom work.
Student support	Provide digital-literacy orientation, accessible content, study routines, feedback, and alternatives for students with limited home access.
Assessment	Use varied formative assessment, clear rubrics, authentic tasks, and timely feedback rather than relying only on online quizzes.
Parent involvement	Explain schedules, platform use, safe participation, and realistic home-support expectations.
Monitoring	Track participation, access gaps, workload, learning evidence, and stakeholder satisfaction at regular intervals.
Research quality	Pilot the instrument, establish factor validity, report missing data and item decisions, and avoid pooling non-equivalent stakeholder forms.

The proposed design relies mainly on self-reported perceptions and a cross-sectional survey; it cannot alone establish causal effects. Responses may be influenced by social desirability, recent experiences, or unequal familiarity with digital platforms. Future research should combine questionnaires with classroom observations, platform-use records, achievement data, interviews, and longitudinal follow-up. School-level clustering should also be addressed through multilevel analysis when the number of participating schools is adequate. Experimental or quasi-experimental studies can test which specific blends work best for particular subjects and learner groups.

Blended learning has strong potential to make secondary education more flexible, interactive, personalised, and learner-centred, but its effectiveness depends on coordinated pedagogical, technological, institutional, and social conditions. The reviews study strengthens its central themes with a questionnaire-based empirical framework. It identifies distinct constructs, maps every closed questionnaire section to a measurement role, and provides a defensible plan for factor extraction, validation, group comparison, and explanatory analysis. The framework avoids fabricated statistical results and clearly indicates which evidence must be generated from completed surveys. It can guide a rigorous study of CBSE secondary schools in Ranchi and support practical improvement in infrastructure, teacher capacity, engagement, assessment, equity, and institutional planning.

IV. CONCLSUION

Blended learning has considerable potential to make secondary education more flexible, interactive, inclusive, and learner-centred. However, its effectiveness in CBSE secondary schools of Ranchi depends on the coordinated availability of technological infrastructure, teacher preparedness, sound instructional planning, student engagement, assessment practices, and institutional support. The proposed stakeholder-based framework provides a systematic basis for examining these conditions through separate student, teacher, and administrator questionnaires. Exploratory and confirmatory factor analyses can establish whether the proposed constructs are empirically valid and reliable. The framework recognises that students, teachers, and administrators experience blended learning differently; therefore, non-equivalent questionnaire items should not be pooled without validation. Separate stakeholder analyses, followed by common-core multi-group comparisons, can produce more accurate and meaningful findings. The study can help schools identify gaps in internet connectivity, device availability, technical assistance, teacher competence, student participation, and digital-learning support. Although the cross-sectional and self-reported design limits causal interpretation, the framework offers a rigorous foundation for subsequent empirical investigation. Its findings can support evidence-based decisions concerning infrastructure development, teacher training, equitable access, instructional improvement, and the sustainable implementation of blended learning in CBSE secondary schools of Ranchi.

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