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ENGAGEMENT AS AN ACADEMIC BOTTLENECK: A NECESSITY-INFORMED PATHWAY REAPPRAISAL OF ENGLISH ACHIEVEMENT IN INDIAN SECONDARY EDUCATION

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Abstract: Background. Research on English achievement in Indian secondary education has long privileged average-effect explanations in which classroom climate, parental involvement, psychological capital, and student engagement are treated as additive predictors. Conceptual gap. Such average-effect framings rarely interrogate whether some learner-level resources function as limiting conditions through which contextual support must pass before reaching observable achievement. Sample and context. The present manuscript draws on a validated school-based cross-sectional study of 1,605 higher-secondary students from 107 government and government-aided schools in West Bengal, India (52.6% female, 66.4% rural). Analytic framework. A necessity-informed pathway reappraisal is developed in which standardized direct and indirect coefficients from the validated structural model are decomposed into a transparent bottleneck-share index that quantifies how contextual antecedents are channelled through engagement and psychological capital. The framework is theoretically grounded but intentionally conservative; no ceiling-line estimation, no necessity effect-size estimation, and no permutation-based necessity test were undertaken. Findings. Student engagement showed the strongest proximal achievement-facing pathway (β = .327), substantially larger than psychological capital (β = .191). The classroom-climate → engagement → achievement indirect pathway (.159) was nearly twice the magnitude of the corresponding psychological-capital channel (.080), and the engagement bottleneck absorbed 51.6% of the total contextual association of classroom climate with English achievement. Methodological contribution. The bottleneck-share framework operationalises necessity-informed reasoning within the conventional standardized-coefficient idiom and offers a transparent bridge between average-effect modelling and future ceiling-line necessary condition analyses. Practical implication. Educational efforts to raise English achievement may benefit most from engagement-supportive instructional practices that translate climate and family support into observable cognitive, emotional, and behavioural classroom participation. Caution. The reported indices are descriptive and associational; the cross-sectional design precludes causal inference, and full Necessary Condition Analysis remains an open agenda for future participant-level data.

Index Terms – English achievement, necessity-informed analysis, engagement bottleneck, pathway decomposition, psychological capital, classroom climate, higher-secondary education, India.

I. INTRODUCTION

English-language proficiency at the higher-secondary stage in Indian education is associated with access to tertiary streams, public-sector employment opportunities, and a wide range of national competitive examinations. Recent state and national learning-outcome reports continue to document substantial within-state variation in English-language performance, particularly in eastern Indian school systems where rural-urban disparities remain salient (Banerji & Wadhwa, 2024; National Council of Educational Research and Training [NCERT], 2023). Identifying which learner-level and contextual factors are statistically linked to English achievement is therefore an enduring concern for researchers, policy actors, and educators.

Four constructs have received the most sustained empirical attention in this literature. Classroom climate — the perceived quality of teacher support, peer cohesion, and orderliness in the immediate learning environment — has been consistently linked with academic engagement and achievement (Wang & Degol, 2016; Daily et al., 2022; Maxwell et al., 2017). Parental involvement, comprising both home-based and school-based forms of family engagement, has been the focus of multiple meta-analyses (Hill &

Tyson, 2009; Boonk et al., 2018; Otani, 2024). Psychological capital — the combination of hope, self-efficacy, resilience, and optimism articulated by Luthans and colleagues (2007) — has been elaborated for educational contexts and associated cross-sectionally with engagement and achievement (Datu & King, 2022; Carmona-Halty et al., 2021; Liu et al., 2023; King et al., 2024). Student engagement, conceptualised by Fredricks and colleagues (2004) as the integration of behavioural, emotional, and cognitive involvement in academic work, is widely treated as the proximal learner-level construct most closely linked to moment-to-moment learning behaviour (Wang et al., 2022; Salmela-Aro et al., 2021; Lerdpornkulrat et al., 2024).

A common pattern in this literature is the use of average-effect modelling — typically structural equation modelling on cross-sectional data — to summarise the joint association of these constructs with achievement. Average-effect framings are informative, but they may obscure a stricter analytic question: whether some learner-level resources function as limiting conditions whose insufficiency cannot easily be compensated by strengths elsewhere in the system. The hypothesis that some resources operate as bottlenecks has a well-defined statistical formulation in Necessary Condition Analysis (NCA) introduced by Dul (2016, 2020), in which an outcome cannot reach a high level unless a condition reaches a minimum level. NCA provides a ceiling-line estimator, a necessity effect-size index, a permutation-based significance test, and an empirical bottleneck table mapping minimum required levels of the condition to desired levels of the outcome (Dul et al., 2023; Richter et al., 2023).

In the context of English learning, NCA-style reasoning is conceptually attractive because high achievement may indeed require some minimum level of engagement, self-efficacy, or resilience. However, full ceiling-line NCA requires raw participant-level item observations to estimate the joint distribution of the condition and the outcome. The present manuscript is positioned more cautiously. Rather than claiming a full NCA, it develops a necessity-informed pathway reappraisal that exploits the bottleneck logic embedded in the validated structural model without overstating evidence the available analytic record cannot support.

Three research questions are addressed in this framework. First, which proximal learner-level construct — engagement or psychological capital — carries the stronger achievement-facing standardized association? Second, what share of the total contextual association of classroom climate and parental involvement with English achievement is channelled through the engagement and psychological-capital pathways respectively? Third, what additional analytic infrastructure would be required to extend the present necessity-informed reasoning into a formal ceiling-line NCA in future participant-level work?

1.1 Contribution of the Present Study

The contribution of this manuscript lies in three places. Conceptually, it reframes a validated English-achievement system through a necessity-informed bottleneck lens, asking not only which predictors carry the strongest average pathways, but also which proximal learner-level construct functions as the primary statistical channel through which contextual support is translated into observable achievement. Methodologically, it operationalises the bottleneck-share framework as a transparent decomposition of total contextual association into engagement-channel, psychological-capital-channel, and direct residual components, computed in closed form from the validated standardized coefficient matrix. Practically, it identifies engagement-supportive instructional design — classroom participation routines, vocabulary-practice scaffolding, reading-engagement structures, and emotional-involvement supports — as the most directly testable implication of a necessity-informed analytic stance, while leaving room for psychological-capital cultivation as a complementary, longer-horizon developmental priority.

II. METHOD

2.1 Design and Participants

The validated dataset that informs this manuscript was generated by a quantitative, cross-sectional, school-based survey design with an English achievement assessment, originally conducted as part of a doctoral research programme on English learning in West Bengal higher-secondary schools (Majumder, 2026). Participants were 1,605 students enrolled in classes XI and XII (mean age = 16.74 years, SD = 0.44; 52.6% female, 47.4% male) recruited from 107 government and government-aided higher-secondary schools across multiple districts of West Bengal, India. Each school contributed exactly 15 students drawn at random from the eligible class registers, yielding a balanced cluster structure (1,605 = 107 × 15). Approximately two-thirds of the participants (66.4%) attended rural schools and one-third (33.6%) attended urban schools, broadly mirroring the regional rural-urban demographic composition of the higher-secondary student population.

Because students were nested within schools, dependency in the data structure cannot be ruled out a priori. School-level identifiers were not retained in the de-identified composite-level analytic file used for the present manuscript; consequently, multilevel modelling and cluster-robust standard errors are not feasible within the present analytic scope. Under the conventional design-effect formulation DEFF = 1 + (m − 1)·ICC with m = 15, plausible intraclass correlations of .05–.10 imply DEFF in the range 1.7–2.4 (Hedges & Hedberg, 2007); reported confidence intervals are therefore interpreted as approximate.

2.2 Measures

Five validated composite scores were used. Classroom Climate (CC) was assessed with a 20-item refined Classroom Climate Scale (range 20–100; Cronbach's α = .94, composite reliability = .95). Parental Involvement (PI) was assessed with a 15-item Perceived Parental Involvement Scale (range 15–75; α = .913, composite reliability = .874). Psychological Capital (PsyCap) was assessed with a 15-item Psychological Capital Assessment Scale measuring hope, self-efficacy, resilience, and optimism (range 15–75; dimension-specific α = .931–.974). Student Engagement (ENG) was assessed with a 12-item Student Engagement Scale measuring cognitive, emotional, and behavioural engagement (range 12–60; subscale α = .840–.866). English Achievement (EAT) was assessed with a 30-item criterion-referenced test aligned with the West Bengal Council of Higher Secondary Education English syllabus (range 0–30; KR-20 = .927). All four self-report instruments were independently validated through exploratory and confirmatory factor analysis on a calibration sample of N = 240 from the same population, with excellent fit indices reported in the source instrument-validation work.

2.3 Procedures and Ethics

The original research was conducted under institutional ethical clearance from Lovely Professional University (approval number LPU/IEC-LPU/2025/6/4, dated 16 December 2025). Written parental consent and student assent were obtained prior to any data collection. The four self-report instruments were administered in classroom settings under standardized written instructions in a

single 45-minute session, and the English achievement test was administered separately under invigilated conditions. All responses were anonymized at entry, with school-level and student-level identifiers replaced by numeric codes prior to any analysis.

2.4 Data Structure and Analytic Scope

The present manuscript was developed using the validated composite-level constructs, verified descriptive statistics, the zero-order correlation matrix, and the standardized structural pathways established in the broader doctoral research programme on English achievement in West Bengal (Majumder, 2026). The analyses reported below are theory-driven methodological extensions of that validated framework rather than reproductions of the original structural equation analyses; the contribution lies in reorganising the validated evidence under a necessity-informed pathway logic that asks distinct conceptual questions from those addressed by the original average-effect SEM.

The analytic workflow used in this manuscript is intentionally conservative and transparent regarding analytic scope. Raw item-level covariance matrices, participant-level response structures, and retained school identifiers were not incorporated into the present analytic workflow; consequently, the manuscript does not estimate a ceiling line, a necessity effect-size coefficient (d), a permutation-based necessity test, or a formal empirical bottleneck table in the sense developed by Dul (2016, 2020) and Dul et al. (2023). In place of these participant-level estimators, the present manuscript develops a bottleneck-share framework that operates within the conventional standardized-coefficient idiom and is, therefore, appropriate to the validated composite-level evidence in hand. The framework should not be interpreted as a full Necessary Condition Analysis; rather, it provides a theoretically grounded analytic extension designed to identify the most promising achievement-facing pathway and to scaffold a future participant-level NCA agenda.

Within this scope, the bottleneck-share index for a contextual antecedent X with respect to achievement Y through a mediator M is defined as the standardized indirect pathway $\beta(X\rightarrow M)\cdot\beta(M\rightarrow Y)$ divided by the total association of X with Y, where the total association is the sum of the direct standardized pathway and all indirect standardized pathways estimated from the validated structural model. The total bottleneck share carried by mediator M over a set of contextual antecedents may therefore be summed and compared to other mediators within the same model. All bottleneck-share values were computed in closed form from the standardized coefficient matrix using the product-of-coefficients method (MacKinnon et al., 2007); no resampling or simulation was introduced.

III. RESULTS

3.1 Descriptive Profile and Variable Dispersion

Table 1 summarises the descriptive profile of the five study constructs. English achievement showed the widest relative dispersion (M = 15.26 on a 0–30 scale; SD = 7.16; coefficient of variation [CV] = 46.92%), substantially greater than the dispersion of any predictor. Classroom climate showed the narrowest relative dispersion (CV = 6.57%), reflecting both a higher mean and the comparatively narrow operational range of teacher-supportive perceptions in the sampled classrooms. Parental involvement (CV = 23.61%), psychological capital (CV = 23.90%), and student engagement (CV = 24.53%) showed broadly comparable moderate dispersion. The wider dispersion of achievement scores compared with the predictors is conceptually relevant for the bottleneck-share reasoning developed below: an outcome with greater relative dispersion is more sensitive to threshold and limiting-condition reasoning than an outcome that clusters tightly around its mean.

Table 1. Descriptive statistics for the five study constructs (N = 1,605).

Construct	Range	M	SD	CV (%)
Classroom Climate (CC)	20–100	60.02	3.95	6.57
Parental Involvement (PI)	15–75	34.83	8.22	23.61
Psychological Capital (PsyCap)	15–75	41.99	10.03	23.90
Student Engagement (ENG)	12–60	33.65	8.26	24.53
English Achievement (EAT)	0–30	15.26	7.16	46.92

Note. M = mean; SD = standard deviation; CV = coefficient of variation, computed as SD/M × 100. Composite scores follow listwise treatment of incomplete records prior to composite computation.

3.2 Pathway Hierarchy in the Validated Structural Model

Table 2 summarises the standardized direct and indirect coefficients on English achievement established in the validated structural model and visualised in Figure 1. Across the four direct pathways, student engagement carried the strongest proximal achievement-facing association (β = .327), approximately 1.71 times the magnitude of the corresponding psychological-capital pathway (β = .191). Parental involvement (β = .106) and classroom climate (β = .069) carried smaller direct associations after the two learner-level mediators were accounted for. The full standardized model accounted for 31.4% of the variance in English achievement (R^2 = .314).

Among the four indirect contextual pathways, the strongest by a clear margin was the classroom-climate → engagement → achievement channel (standardized indirect = .159), followed by classroom-climate → psychological-capital → achievement (.080), parental-involvement → engagement → achievement (.077), and parental-involvement → psychological-capital → achievement (.054). The engagement-mediated indirect channel therefore exceeded the corresponding psychological-capital-mediated channel for both contextual antecedents — nearly twice the magnitude for classroom climate (.159 vs .080) and about 1.4 times for parental involvement (.077 vs .054).

Table 2. Standardized direct and indirect pathways on English achievement.

Pathway	Standardized coefficient	Type	Rank
ENG → EAT	.327	Direct	1
PsyCap → EAT	.191	Direct	2
CC → ENG → EAT	.159	Indirect	3
PI → EAT	.106	Direct	4
CC → PsyCap → EAT	.080	Indirect	5
PI → ENG → EAT	.077	Indirect	6
CC → EAT (residual)	.069	Direct	7
PI → PsyCap → EAT	.054	Indirect	8

Note. CC = Classroom Climate; PI = Parental Involvement; PsyCap = Psychological Capital; ENG = Student Engagement; EAT = English Achievement. Direct pathways are standardized SEM estimates; indirect pathways are products of constituent standardized coefficients. Full standardized model R^2 = .314 for English achievement.

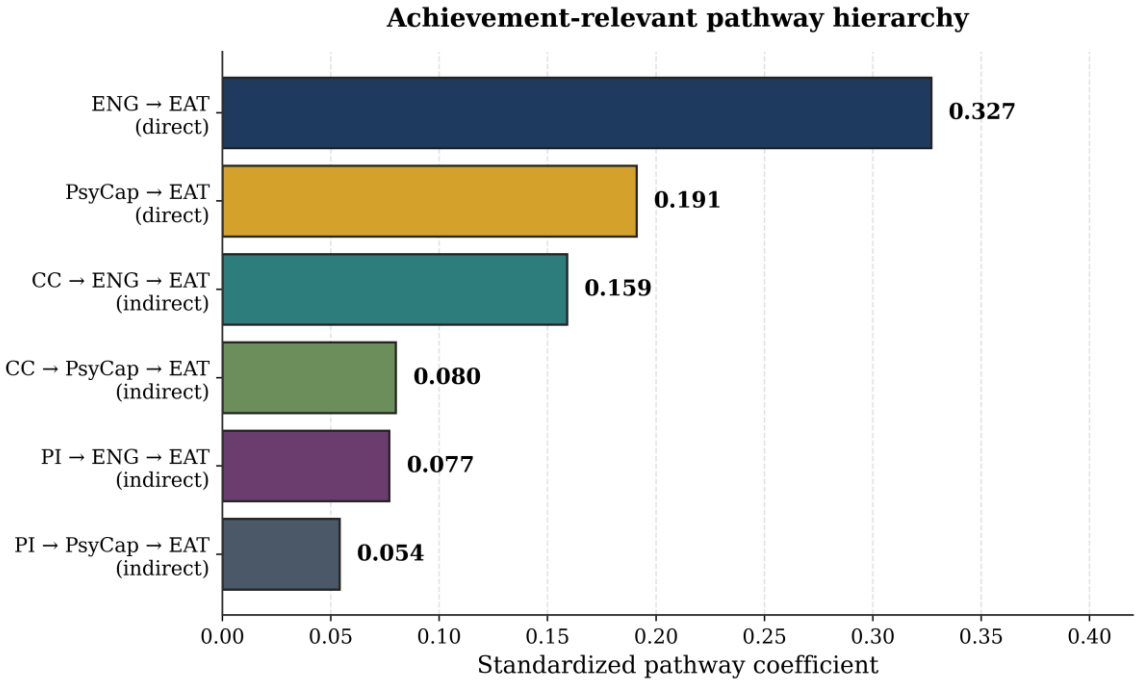

Figure 1. Achievement-relevant pathway hierarchy. Direct pathways (engagement and psychological capital) and indirect contextual pathways (through internal mediators) are ordered by standardized magnitude. Bar lengths are proportional to standardized coefficients.

3.3 Bottleneck-Share Decomposition

To address the second research question, a bottleneck-share index was computed for each contextual antecedent. For a contextual antecedent X, the bottleneck-share carried by mediator M with respect to outcome Y is defined as

$$BS(X, M, Y) = [\beta(X \rightarrow M) \cdot \beta(M \rightarrow Y)] / TA(X, Y),$$

where TA(X, Y) is the total association of X with Y, calculated as the sum of the direct standardized pathway and all indirect standardized pathways traversing each available mediator. Within the present validated model, TA(CC, EAT) = .069 + .159 + .080 = .308 and TA(PI, EAT) = .106 + .077 + .054 = .237. Substituting the validated coefficients yields the bottleneck-share decomposition reported in Table 3 and visualised in Figure 2.

For classroom climate, the engagement bottleneck absorbed 51.6% of the total contextual association (.159 of .308), the psychological-capital bottleneck absorbed 26.0% (.080 of .308), and the residual direct share accounted for 22.4% (.069 of .308). For parental involvement, the engagement bottleneck absorbed 32.5% of the total association, the psychological-capital bottleneck absorbed 22.8%, and the residual direct share accounted for 44.7%. Across both contextual antecedents, the engagement bottleneck consistently outweighed the psychological-capital bottleneck.

Table 3. Bottleneck-share decomposition of the total contextual association with English achievement.

Contextual antecedent	Engagement bottleneck	PsyCap bottleneck	Residual direct	Total association
Classroom Climate	.159 (51.6%)	.080 (26.0%)	.069 (22.4%)	.308 (100%)
Parental Involvement	.077 (32.5%)	.054 (22.8%)	.106 (44.7%)	.237 (100%)

Note. Each cell reports the standardized indirect or direct pathway and its share of the total association of the contextual antecedent with English achievement. Total association = direct + sum of indirect pathways through engagement and psychological capital.

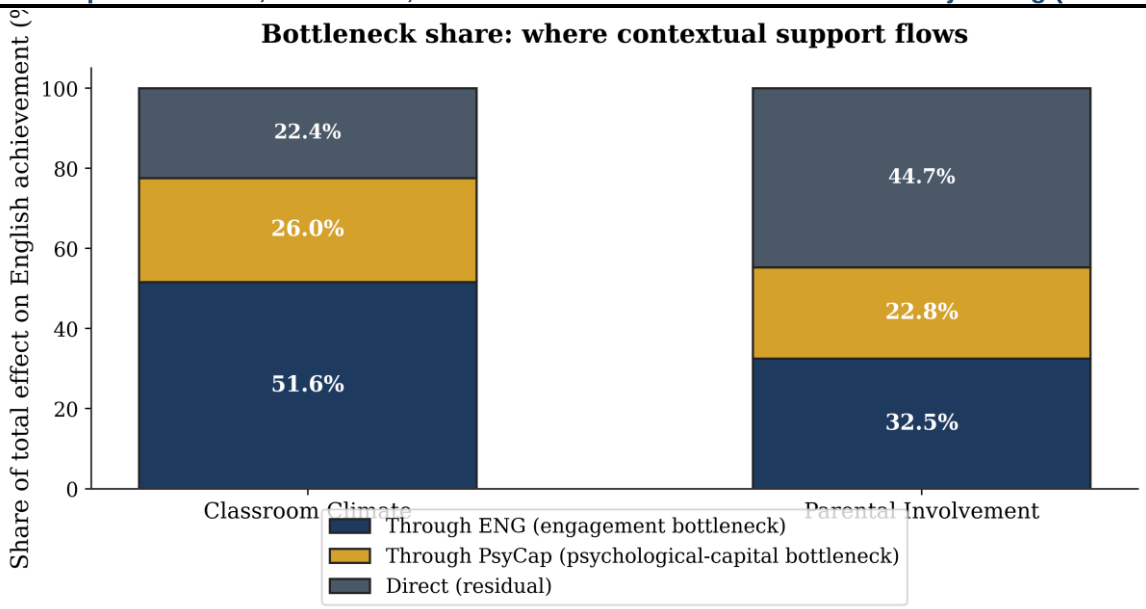

Figure 2. Bottleneck-share decomposition of the total contextual association of classroom climate and parental involvement with English achievement, partitioned into engagement-channel, psychological-capital-channel, and residual direct components.

3.4 Necessity-Informed Interpretation

The pathway hierarchy and bottleneck-share decomposition together support a single interpretive claim: within the validated model, student engagement appears to function as the strongest proximal achievement-facing pathway through which classroom climate and parental involvement are translated into English achievement. The claim is associational and descriptive; it does not assert that engagement is the sole necessary condition for English achievement, nor that psychological capital is unimportant for academic functioning. It asserts a more limited and defensible point: among the proximal learner-level mediators available in the validated model, engagement carries a larger share of the contextual-to-achievement association than psychological capital does.

The third research question asked what additional analytic infrastructure would be required to convert the present necessity-informed reasoning into a formal ceiling-line NCA. Five elements are required at the participant level: (a) raw item-level scores for each predictor and the outcome, so that the joint distribution of (X, Y) can be recovered; (b) ceiling-line estimation using either the upper-left ceiling FDH (free disposal hull) or CR-FDH (ceiling regression FDH) procedure of Dul (2016, 2020); (c) the necessity effect-size coefficient d = (C − b)/S, where C is the ceiling-zone area, b is the empty zone above the ceiling line, and S is the total scope of the X-Y plane; (d) a permutation test against the null hypothesis of no necessity-type relation; and (e) a bottleneck table mapping minimum required levels of X to desired levels of Y. None of these participant-level estimators is available within the present analytic scope. Future studies that gain access to participant-level item data should estimate these formal NCA quantities for engagement and for the four constituent dimensions of psychological capital before strong necessary-condition claims are advanced in this literature.

IV. DISCUSSION

This manuscript reframes a validated English-achievement system through a necessity-informed pathway lens. Within that lens, the strongest proximal achievement-facing pathway is engagement (β = .327), and the engagement bottleneck absorbs 51.6% of the total contextual association of classroom climate with English achievement. Psychological capital remains substantively important — it carries a non-trivial direct pathway (β = .191) and a meaningful share of contextual indirect association — but the bottleneck-share decomposition consistently positions engagement as the larger statistical channel for both contextual antecedents.

These findings extend the engagement literature in two ways. First, they confirm the engagement-as-proximal-mechanism interpretation that has been articulated within social cognitive theory (Bandura, 1986; Schunk & DiBenedetto, 2021), extended through autonomy-support frameworks (Reeve & Cheon, 2021), and consolidated in recent reviews (Wang et al., 2022; Wong & Liem, 2022; Lerdpornkulrat et al., 2024) and longitudinal evidence in adjacent fields (Salmela-Aro et al., 2021; Skinner et al., 2022; Tomaszewski et al., 2022). Second, they operationalise that interpretation as a transparent quantitative decomposition. The bottleneck-share index is not a substitute for ceiling-line NCA, but it does offer a closed-form bridge between the average-effect SEM tradition and the necessity-condition tradition; it asks a different question — what proportion of total association traverses each proximal channel — and answers it using only the standardized coefficient matrix.

The corresponding pattern for parental involvement is more nuanced. The residual direct share for parental involvement (44.7%) was the single largest component — larger than either the engagement-bottleneck share (32.5%) or the psychological-capital bottleneck share (22.8%) individually — suggesting that family processes may operate on English achievement through additional channels not captured by the present learner-level mediator pair — plausibly through academic socialisation, expectations, home learning structure, or out-of-school tuition support (Otani, 2024; Boonk et al., 2018; Pomerantz et al., 2022). The bottleneck-share framework therefore applies most cleanly to the classroom-climate channel and identifies parental involvement as a candidate construct for a more elaborate mediator inventory in future work.

Practical implications for English-language instruction in Indian higher-secondary classrooms follow from the engagement-as-bottleneck reading. Classroom routines that translate teacher-supportive climate into observable cognitive participation (active vocabulary practice, structured reading-engagement tasks, formative writing tasks with feedback), behavioural participation (sustained on-task behaviour, persistence in difficult passages, attendance and homework completion), and emotional participation (interest, enjoyment, sense of relevance) may carry larger statistical weight on achievement than interventions that target psychological capital alone. This does not displace the value of psychological-capital cultivation as a longer-horizon developmental

priority; it suggests that engagement-supportive instructional design is the more proximal lever within the associational structure documented here.

4.1 Limitations and Boundaries of Inference

Three boundaries of inference should be acknowledged. First, the manuscript is positioned as necessity-informed rather than as a full Necessary Condition Analysis. A formal NCA would require participant-level raw scores, ceiling-line estimation, permutation testing, and an empirical bottleneck table; these analyses remain an open agenda for future research with access to item-level data. Second, the cross-sectional design precludes causal inference: engagement may statistically channel contextual support to achievement at one time point, achievement may shape engagement reciprocally over time, or both may be jointly produced by unmeasured antecedents; these alternatives cannot be distinguished from the present analytic record. Third, school-level identifiers were not retained in the composite-level file used here; the multilevel structure of the data could not be modelled explicitly, and reported confidence intervals are interpreted as approximate. None of these boundaries undermines the descriptive validity of the bottleneck-share decomposition; they delimit the inferential scope within which the decomposition is most defensibly used.

V. CONCLUSION

Within a validated English-achievement system from Indian higher-secondary education, engagement appears to function as the strongest proximal achievement-facing pathway: it carries the largest direct standardized association with English achievement and it absorbs the largest share of the total contextual association of classroom climate with English achievement. Psychological capital remains a meaningful complementary resource, but the bottleneck-share decomposition does not support its interpretation as the sole limiting condition for English achievement. The necessity-informed pathway framework developed here provides a defensible bridge between average-effect modelling and future ceiling-line necessary-condition work, and it sharpens the practical implication that engagement-supportive instructional design is a leading candidate for translating supportive classroom contexts into observable English-language gains.

DECLARATIONS

Ethics Statement. The original data collection was conducted under institutional ethical clearance from Lovely Professional University (approval number LPU/IEC-LPU/2025/6/4, dated 16 December 2025). Written parental consent and student assent were obtained from all participants.

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Conflict of Interest. The authors declare no conflict of interest.

Data Availability. The de-identified composite-level data file and the closed-form analytic scripts that support the present manuscript are available from the corresponding author on reasonable request and subject to institutional approval.

Author Contributions. P.M. conceptualised the necessity-informed pathway framework, conducted the closed-form analyses, and drafted the manuscript. N.B. supervised the broader doctoral research programme and contributed to the revision of the framework. P.S. and N.K. contributed to interpretation, theoretical positioning, and critical revision of the manuscript. All authors approved the final version.

Use of Artificial Intelligence. Generative-AI tools were used for sentence-level editorial polishing and consistency checks. All conceptual framing, analytic decisions, and substantive interpretation are the work of the authors. No AI tool was used to generate data, statistical estimates, or reference entries; all references were independently verified.

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