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Original Research Article

UNDERSTANDING VERSUS SCORING: LEARNING APPROACHES AND EDUCATIONAL OUTCOMES IN UNDERGRADUATE PHYSIOLOGY

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ABSTRACT

Background: Academic marks may not fully represent meaningful understanding of physiology. This study examined whether deep, strategic and surface learning approaches were differently associated with conceptual understanding and conventional academic performance among undergraduate medical students.
Materials and Methods: This cross-sectional analytical study included 139 Phase I MBBS students. Learning approaches were assessed using the 18-item short-form Approaches and Study Skills Inventory for Students (ASSIST). Conceptual understanding was evaluated using a content-validated Physiology Conceptual Understanding Test (PCUT), while academic performance was obtained from institutional physiology assessment records. Outcomes were compared across predominant learning approaches using ANOVA, and associations were examined using Pearson's correlation and multiple linear regression.
Results: Strategic learning was the most frequent predominant approach (41.7%), followed by deep (34.5%) and surface learning (17.3%). PCUT scores were highest among deep learners (74.8±8.8%) and lowest among surface learners (59.6±9.8%; $p<0.001$). Conversely, academic scores were highest among strategic learners (76.1±7.2%) and lowest among surface learners (64.2±8.9%; $p<0.001$). Deep learning correlated most strongly with conceptual understanding ($r=0.46$, $p<0.001$) and remained its strongest positive predictor ($\beta=0.35$, $p<0.001$). Strategic learning was the strongest predictor of academic performance ($\beta=0.42$, $p<0.001$), whereas surface learning independently predicted poorer conceptual ($\beta=-0.32$, $p<0.001$) and academic performance ($\beta=-0.27$, $p=0.001$).
Conclusion: Deep learning was more strongly associated with conceptual understanding, whereas strategic learning showed the strongest association with examination performance. Surface learning was detrimental to both outcomes, highlighting the need for physiology teaching and assessment that extends beyond marks toward meaningful conceptual learning.
Keywords: Academic performance; conceptual understanding; deep learning; learning approaches; medical education.

INTRODUCTION

Physiology is a foundational discipline in medical education because understanding mechanisms such as homeostasis, feedback regulation, pressure–flow relationships and structure–function interactions is essential for interpreting disease processes and applying basic science in clinical settings. However, physiology is frequently perceived as difficult because students must integrate knowledge across multiple organisational levels and reason about dynamic, interacting systems rather than merely recall isolated facts.[1] Consequently, examination marks alone may not adequately reflect whether students have developed transferable conceptual understanding of physiological mechanisms.[2]

Students differ substantially in how they approach learning. The widely used approaches-to-learning framework describes three broad orientations: deep, strategic, and surface learning. Deep learners seek meaning, relate new information to prior knowledge and integrate ideas; strategic learners organise their study, manage time and adapt effort to maximise achievement; whereas surface learners tend to rely on rote memorisation and minimum task requirements.[3] Importantly, these approaches are not fixed learner traits and may change according to curriculum, teaching methods, workload and assessment demands.[4]

Evidence from medical education suggests that these approaches may have different consequences for learning. An Indian study demonstrated that clinically oriented physiology teaching increased deep learning while reducing surface learning.[5], and subsequent work from Karnataka found significantly greater deep and strategic approaches among students exposed to a partially problem-based physiology curriculum.[6] Academic outcomes show a similar pattern: among 130 preclinical medical students, high achievers reported significantly greater deep and strategic learning, whereas low achievers relied more heavily on surface learning ($p<0.05$).[7] Nevertheless, associations between learning approaches and conventional examination performance have not been entirely consistent.[8] More recently, a South Indian physiology study involving 109 students found that deep learning positively predicted constructed-response performance ($\beta=0.032$), while surface learning predicted poorer performance ($\beta=-0.038$), yet neither clearly predicted multiple-choice performance.[9]

These observations highlight an important distinction between scoring well and understanding well. Evidence simultaneously examining deep, strategic and surface approaches in relation to both conceptual understanding and routine academic achievement in undergraduate physiology remains limited. The present study was therefore aimed to determine whether students' learning approaches influence these two related but potentially distinct educational outcomes.

MATERIALS AND METHODS

Study design and setting: A cross-sectional analytical study was conducted among Phase I undergraduate medical students enrolled in the MBBS programme at a tertiary-care teaching institution during the academic year 2025–2026. The study was undertaken in the Department of Physiology after students had completed the major organ-system modules and at least one formal internal assessment, thereby ensuring adequate exposure to both physiology teaching and institutional assessment. Data collection was performed only after the relevant examination results had been finalised to minimise response bias related to anticipated grades.

Study participants and sample size: All first-year MBBS students who had attended the physiology course and completed the corresponding internal assessment were eligible. Students who declined participation, submitted substantially incomplete questionnaires, or were absent during either learning-approach or conceptual-understanding assessment were excluded. Assuming a minimum correlation of 0.25 between learning-approach scores and academic outcomes, with 80% power and a two-sided α of 0.05, the minimum sample required was approximately 123. After allowing for about 10% incomplete/non-response data, the target sample was 137 students. Considering the finite class strength, total-enumeration sampling was adopted and all eligible students were invited.

Assessment of learning approaches: Learning approaches were assessed using the 18-item short form of the Approaches and Study Skills Inventory for Students (ASSIST), which assesses deep, strategic and surface approaches to studying.[7] Each domain contains six statements rated on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree), producing domain scores ranging from 6 to 30. Higher scores indicate greater use of the respective approach. Deep, strategic and surface scores were analysed primarily as continuous variables. For descriptive comparisons, the approach with the highest domain score was considered the participant's predominant learning approach. Students with equal highest scores in two domains were classified as having a mixed approach. Internal consistency of each ASSIST domain was examined using Cronbach's α.

Assessment of conceptual understanding: Conceptual understanding was evaluated independently of routine examination marks using a specifically developed Physiology Conceptual Understanding Test (PCUT). The test comprised 25 single-best-answer, application-oriented questions covering major physiological concepts taught during the study period, including homeostasis, membrane and cellular physiology, cardiovascular, respiratory, renal, gastrointestinal, endocrine and nervous-system physiology. Questions were constructed predominantly at understanding and application levels of the revised Bloom taxonomy and emphasised interpretation, prediction, causal reasoning and application of physiological principles rather than factual recall. A detailed content blueprint was prepared, and the items were independently reviewed by senior physiology faculty for relevance, clarity and cognitive level. Items requiring substantial revision were modified before administration. One mark was awarded for each correct response without negative marking, yielding a score of 0–25, subsequently expressed as a percentage. Internal consistency was assessed using the Kuder–Richardson-20 coefficient.

Measurement of academic performance: Academic performance was obtained from official departmental records rather than student self-report. The aggregate percentage obtained in the most recent institutional physiology assessment, comprising the prescribed theory and practical components, was used as the measure of routine academic achievement. Marks were linked to study questionnaires through anonymised identification codes. Thus, conceptual understanding and conventional academic performance were treated as separate outcome variables, allowing assessment of whether a learning approach associated with higher examination marks also reflected superior conceptual understanding.

Data collection procedure: Participants completed the ASSIST questionnaire under uniform, non-examination conditions after receiving standardised instructions. The PCUT was administered subsequently under supervised classroom conditions with a predetermined time limit. Information regarding age, sex, previous academic performance, average self-reported study duration, class attendance and use of additional learning resources was collected using a brief structured proforma as potential covariates. Participation was voluntary and had no bearing on academic evaluation.

Statistical analysis: Data were analysed using IBM SPSS Statistics. Continuous variables were summarised as mean±standard deviation or median with interquartile range, as appropriate, while categorical variables were expressed as frequencies and percentages. Internal consistency of the deep, strategic and surface ASSIST domains was assessed using Cronbach's α. The predominant learning approach was determined from the highest individual ASSIST domain score; equal highest scores were classified as mixed/tied. Conceptual-understanding (PCUT) and academic-performance scores were compared across predominant learning-approach groups using one-way analysis of variance (ANOVA), followed by Tukey's post-hoc test for pairwise comparisons. Effect size for between-group differences was expressed as eta-squared (η^2). Pearson's correlation coefficient was used to examine associations between continuous deep, strategic and surface ASSIST scores and PCUT and academic-performance scores. Separate multiple linear regression models were constructed for PCUT and academic performance, with the three learning-approach scores entered simultaneously and adjustment for sex, Class XII academic performance and physiology attendance. Unstandardised coefficients (B), standard errors, standardised coefficients (β), and 95% confidence intervals were reported; model performance was expressed using R^2 and adjusted R^2. Normality, linearity, homoscedasticity, independence of residuals and multicollinearity were examined before interpreting the regression models. All statistical tests were two-sided, and $p<0.05$ was considered statistically significant.

Ethical considerations: The study was initiated after approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants. Participation was voluntary, responses were anonymised, and individual learning-approach scores were not disclosed to faculty involved in students' academic assessment.

RESULTS

The mean age of participants was 19.2±0.9 years, with females comprising 54.7%. Most students had English-medium schooling (74.1%), while 41.7% belonged to rural areas. Mean Class XII percentage and physiology attendance were 86.3±5.7% and 87.6±5.9%, respectively. The mean conceptual-understanding (PCUT) score was 70.2±10.2%, compared with a mean institutional physiology assessment score of 72.5±8.7% [Table 1]

Table 1: Sociodemographic and academic characteristics of undergraduate medical students (N=139).

Characteristic	Frequency (%)/mean ± SD
Age, years	19.2 ± 0.9
Gender	
Male	63 (45.3)
Female	76 (54.7)
Residence	
Urban	81 (58.3)
Rural	58 (41.7)
Schooling	
English-medium	103 (74.1)
Hindi/regional-medium	36 (25.9)
Class XII aggregate percentage	86.3 ± 5.7
Physiology attendance, %	87.6 ± 5.9
Average self-study, hours/day	2.8 ± 1.1
PCUT score, %	70.2 ± 10.2
Institutional physiology assessment, %	72.5 ± 8.7

PCUT, Physiology Conceptual Understanding Test: Strategic learning was the most frequent predominant approach, observed in 58 (41.7%) students, followed by deep learning in 48 (34.5%), surface learning in 24 (17.3%), and a mixed/tied approach in 9 (6.5%). Strategic learning also had the highest mean ASSIST score (24.2±3.6), followed by deep (23.4±3.4) and surface learning (18.5±4.1). Internal consistency was satisfactory across the three domains (Cronbach's α=0.76–0.82) [Table 2]

Table 2: Distribution and scores of deep, strategic and surface learning approaches assessed using the short-form ASSIST (N=139).

Learning approach	ASSIST score, mean ± SD	Median (IQR)	Predominant approach, n (%)	Cronbach's α
Deep	23.4 ± 3.4	24 (21–26)	48 (34.5)	0.78
Strategic	24.2 ± 3.6	24 (22–27)	58 (41.7)	0.82
Surface	18.5 ± 4.1	18 (16–21)	24 (17.3)	0.76
Mixed/tied approach	—	—	9 (6.5)	—

ASSIST, Approaches and Study Skills Inventory for Students.

Conceptual-understanding scores differed significantly across learning approaches (F=16.20, p<0.001; η²=0.265), being highest among deep learners (74.8±8.8%) and lowest among surface learners (59.6±9.8%). Academic scores also differed significantly (F=13.98, p<0.001; η²=0.237), with strategic learners obtaining the highest mean score (76.1±7.2%) and surface learners the lowest (64.2±8.9%). Post-hoc comparisons confirmed significantly poorer outcomes among surface learners compared with deep and strategic learners [Table 3]

Table 3: Comparison of conceptual understanding and academic performance according to predominant learning approach (N=139).

Predominant approach	PCUT score, %,	Academic score, %,
	mean ± SD	
Deep (n=48)	74.8 ± 8.8	72.8 ± 7.6
Strategic (n=58)	71.2 ± 8.6	76.1 ± 7.2
Surface (n=24)	59.6 ± 9.8	64.2 ± 8.9
Mixed/tied (n=9)	67.6 ± 8.5	69.8 ± 7.7
Overall ANOVA	F=16.20; p<0.001	F=13.98; p<0.001
Effect size (η²)	0.265	0.237

PCUT, Physiology Conceptual Understanding Test

Deep learning showed its strongest positive association with conceptual understanding (r=0.46, p<0.001), whereas strategic learning showed the strongest association with academic performance (r=0.47, p<0.001). Surface learning was negatively correlated with both PCUT (r=−0.43, p<0.001) and academic scores (r=−0.36, p<0.001). Conceptual understanding and academic performance themselves were moderately positively correlated (r=0.58, p<0.001) [Table 4]

Table 4: Correlation of deep, strategic and surface learning-approach scores with conceptual understanding and academic performance (N=139).

Variable	PCUT score, r	p-value	Academic score, r	p-value
Deep approach score	0.46	<0.001	0.29	<0.001
Strategic approach score	0.24	0.004	0.47	<0.001
Surface approach score	−0.43	<0.001	−0.36	<0.001
PCUT score	—	—	0.58	<0.001

PCUT, Physiology Conceptual Understanding Test; r, Pearson's correlation coefficient.

Deep learning was the strongest independent positive predictor of PCUT performance (β=0.35, p<0.001), while strategic learning showed a smaller positive association (β=0.18, p=0.025). Surface learning independently predicted poorer conceptual understanding (β=−0.32, p<0.001). Physiology attendance was also positively associated with PCUT scores (p=0.016), whereas Class XII performance and sex were not significant. The model explained 44% of the variance in conceptual-understanding scores (R^2=0.44; adjusted R^2=0.41; p<0.001) [Table 5]

Table 5: Multiple linear regression analysis of factors independently associated with physiology conceptual-understanding score (N=139).

Predictor	B	SE	Standardised β	95% CI for B	p-value
Deep approach score	1.06	0.24	0.35	0.59 to 1.53	<0.001
Strategic approach score	0.52	0.23	0.18	0.07 to 0.97	0.025
Surface approach score	−0.81	0.2	−0.32	−1.21 to −0.41	<0.001
Class XII percentage	0.1	0.09	0.06	−0.08 to 0.28	0.268
Physiology attendance (%)	0.22	0.09	0.13	0.04 to 0.40	0.016
Female Gender	0.84	1.25	0.04	−1.63 to 3.31	0.503

PCUT, Physiology Conceptual Understanding Test; B, unstandardised regression coefficient; SE, standard error; β, standardised regression coefficient; CI, confidence interval; R^2, coefficient of determination.

Strategic learning emerged as the strongest independent predictor of academic performance (β=0.42, p<0.001), followed by an inverse association with surface learning (β=−0.27, p=0.001) and a positive association with deep learning (β=0.19, p=0.009). Class XII performance (p=0.014) and physiology attendance (p=0.024) were also independently associated with academic scores, while sex was not. The model explained 52% of the variability in academic performance (R^2=0.52; adjusted R^2=0.50; p<0.001) [Table 6]

Table 6: Multiple linear regression analysis of factors independently associated with academic performance in physiology (N=139).

Predictor	B	SE	Standardised β	95% CI for B	p-value
Deep approach score	0.48	0.18	0.19	0.12 to 0.84	0.009
Strategic approach score	1.03	0.18	0.42	0.67 to 1.39	<0.001
Surface approach score	−0.56	0.16	−0.27	−0.88 to −0.24	0.001
Class XII percentage	0.2	0.08	0.14	0.04 to 0.36	0.014
Physiology attendance (%)	0.16	0.07	0.11	0.02 to 0.30	0.024
Female Gender	0.72	1.03	0.04	−1.32 to 2.76	0.487

B, unstandardised regression coefficient; SE, standard error; β, standardised regression coefficient; CI, 95% confidence interval; R^2, coefficient of determination.

DISCUSSION

The present study demonstrates that learning approach is associated with both conceptual understanding and academic performance in undergraduate physiology, but with distinctly different patterns. Strategic learning was the most frequent predominant approach (41.7%), followed by deep (34.5%) and surface learning (17.3%). Chonkar et al., similarly reported strategic learning in 50.8%, deep learning in 40.3%, and surface learning in 8.8% of medical students,[10] while Rehman et al., observed a predominantly strategic approach in 71.4% of first-year students.[11] Strategic learning was also predominant across undergraduate and postgraduate groups in Sri Lanka.[12] These variations probably reflect differences in curriculum, assessment intensity and learning environment, supporting evidence that approaches to learning are context-responsive rather than fixed student characteristics.[13,14]

The strongest finding concerned conceptual understanding. Deep learners achieved higher PCUT scores (74.8±8.8%) than strategic (71.2±8.6%) and surface learners (59.6±9.8%; F=16.20, p<0.001; η^2=0.265). Deep-approach score correlated moderately with PCUT performance (r=0.46, p<0.001) and remained its strongest positive predictor after adjustment (β=0.35, p<0.001). Ramezani et al., similarly found deep learning positively associated with academic performance (r=0.538) and constructive problem-solving.[15] Papinczak et al., also demonstrated the relevance of deep-strategic orientations within problem-based medical learning.[16] Physiologically, this association is credible because conceptual understanding requires integration of mechanisms, causal reasoning and transfer of principles such as homeostasis and feedback to unfamiliar situations. Deep processing builds interconnected knowledge structures, enabling students to explain why a physiological response occurs rather than merely reproduce its sequence.

In contrast, strategic learning showed the strongest relationship with conventional academic achievement. Strategic learners obtained the highest academic score (76.1±7.2%), compared with deep (72.8±7.6%) and surface learners (64.2±8.9%; F=13.98, p<0.001; η^2=0.237). Strategic score correlated with examination marks (r=0.47, p<0.001) and was their strongest independent predictor (β=0.42, p<0.001). Ward et al., reported that approaches to study influenced outcomes throughout preclinical medical education.[17], while Reid et al., demonstrated that associations between learning approach and performance varied with assessment characteristics.[18] Similarly, May et al., found deep and strategic approaches associated with better components of high-stakes clinical performance.[19] Strategic learners are typically effective at time management, organising material, identifying assessment priorities and regulating effort; these behaviours may maximise marks even when an examination only partly measures conceptual transfer.

Surface learning, conversely, was consistently disadvantageous. It correlated negatively with conceptual understanding (r=−0.43) and academic scores (r=−0.36), and independently predicted poorer PCUT (β=−0.32) and academic performance (β=−0.27). Mattick et al., also demonstrated relationships between approaches to studying and medical-student performance.[20], while Feeley et al., concluded that deep and strategic approaches are generally more favourable for examination success than surface approaches.[21] Mechanistically, rote memorisation produces relatively fragmented representations; these may support immediate factual recall but are less accessible when learners must integrate organ systems, predict consequences or solve novel physiological problems. Thompson et al., recent work further indicates that associations can vary by examination and cognitive demand.[22]

The broader literature reinforces this interpretation. A systematic review by Roehe et al., of 49 medical and dental education studies found higher performance in 53.3% of strategic-performance associations, whereas surface learning was associated with poorer performance in 50% and higher performance in only about 1%.[23] Longitudinal studies by Piumatti et al., and Qureshi et al., further show that learning approaches can change during medical training and that trajectories characterised by deeper learning are associated with more favourable subsequent outcomes.[24,25] Reid et al., similarly demonstrated changes across the medical degree.[26], while Qureshi et al., identified significant variation in deep learning across year levels.[25]

Finally, conceptual and academic scores were only moderately correlated ($r=0.58$, $p<0.001$), reinforcing the central premise of "beyond marks": examination success and conceptual mastery overlap but are not synonymous. The findings support assessment systems that combine conventional examinations with application-oriented problems, explanation of mechanisms and clinically contextualised physiology. Rather than labelling students permanently as particular "types," educators should promote the complementary strengths of deep understanding and strategic self-regulation while identifying and addressing excessive reliance on surface memorisation.

Limitations: This study has several limitations. Its cross-sectional, single-centre design precludes causal inference and may limit generalisability to other medical schools. Learning approaches were measured using a self-reported questionnaire and may be affected by social-desirability or recall bias. The conceptual-understanding test, although content-validated, was locally developed. Residual confounding from motivation, stress, sleep, socioeconomic factors and prior learning strategies cannot be excluded. Longitudinal multicentre studies are warranted.

CONCLUSION

In undergraduate physiology, learning approaches were differentially associated with conceptual understanding and conventional academic performance. Deep learning showed the strongest independent relationship with conceptual understanding, whereas strategic learning was most strongly associated with examination achievement. Surface learning was consistently associated with poorer outcomes in both domains. These findings suggest that high marks do not necessarily represent the same educational construct as mechanistic understanding. Physiology curricula should therefore promote deep processing alongside strategic self-regulation and should incorporate assessment tasks that reward application, causal reasoning, and transfer rather than factual reproduction alone. Early identification of predominant surface learning may also provide an opportunity for targeted academic and metacognitive support.

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