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Evaluation of Learner Insights on Innovative Teaching Strategies in Integrated Modular Biochemistry Curriculum

Nabeela Faisal, Fauzia Jan, Lubna Aftab, Zehra Niazi, Sabahat Ikhlaq, Nawal Amjad

ABSTRACT

Objective: To test new instructional strategies in the integrated modular Biochemistry curriculum based on learner behaviors, knowledge retention, and student-centered education.

Study Design and Setting: This was an observational cross-sectional study conducted at the Department of Biochemistry, University Medical & Dental College, a constituent medical college of The University of Faisalabad, utilizing an integrated modular curriculum. Surveys were undertaken of undergraduate medical faculty members and students to explore their perceptions of innovative teaching strategies.

Methodology: A total of 352 respondents were invited, comprising 300 learners and 52 teachers. Data was collected using a structured questionnaire that measured perceptions of interactive sessions involving large groups of students, tutorials/SGDs, case-based learning, and flip classrooms. Pearson's Chi-square and likelihood ratio tests were used to test the association between variables.

Results: A total of 352 respondents participated. For the integrated modular curriculum, 47.3% of students agreed and 12% strongly agreed that it complemented their knowledge and promoted participation. Regarding tutorials/SGDs, 55% agreed and 15% strongly agreed that these sessions encouraged a student-centered approach. In case-based learning, 48% agreed and 16.3% strongly agreed that it was intellectually stimulating and challenging. For the flipped classroom, 37.7% agreed and 10.3% strongly agreed that it was a useful innovation, although a considerable proportion remained neutral

Conclusion: Research indicates that interactive teaching methods in biochemistry are favorably received, enhance active learning, and are of value within integrated curricula. A wider application can improve the performance of medical education.

Keywords: Biochemistry, Curriculum, Faculty, Medical Education, Instructional Methods, Students

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INTRODUCTION

Medical education has undergone pround transformation in last 10 years, shifting from conventional discipline-based curricula toward integrated, learner-centered approaches. This evolution emphasizes active and contextual learning, shifting from passive reception of information to fostering critical engagement. As a core foundational science, biochemistry plays an important role within this modern framework. It provides the important basis for understanding crucial medical concepts like human physiology, pathophysiology, and molecular pathogenesis. By elucidating the biochemical mechanisms underlying health and disease, it bridges foundational science and clinical practice, enabling future healthcare professionals to comprehend bodily processes at a molecular level and equipping them with the knowledge necessary for rational diagnosis and treatment.[1]

Integrated teaching is a learner-centered strategy that combines overlapping concepts from different disciplines, both horizontally within a phase and vertically across phases, to improve clinical relevance, decrease redundancy, and develop a holistic understanding. It connects teaching both temporally and thematically to enhance contextual, competency-based learning in undergraduate medical education.[2]

The four-level Kirkpatrick model, which is still one of the

most popular frameworks for evaluating the effectiveness of educational interventions, offers a methodical way to evaluate the success of both official and informal training programs by analyzing learners' responses, learning, behavior, and outcomes.[3] The paradigm emphasizes knowledge acquisition and instant gratification, as well as the practical applications of skills and their wider influence on organizational results.

With more than 95% of students reporting a favorable influence on their learning experience, Kulkarni et al. showed that the use of various case scenarios in integrated teaching greatly improved conceptual clarity, motivation and critical thinking among first-year students[4]

Due to the abstract concepts, as well as the content and apparent lack of clinical correlation, Biochemistry has often been perceived as a challenging subject by undergraduate medical students. Worldwide, Medical Schools have begun to address these issues by incorporating new methods of teaching and learning to improve levels of student engagement, retention, and preparation for clinical practice through the implementation of integrated modular curricula (IMCs).[5]

Because the integrated modular curriculum is grounded in systems or topics rather than subject courses, correlations can be combined both horizontally and vertically. Some illustrative contemporary innovations within this paradigm that encourage active and meaningful learning include flipped classrooms, case-based learning (CBL), tutorial instruction, large-group interactive sessions (IGS), and small-group discussions (SGDs).[6] Feedback and conceptual understanding are stimulated through large-group interactions, whereas a more profound understanding is facilitated through socialization with both peers and professors in SGD-tutorials. Therefore, by linking biochemical concepts to patient-oriented cases, CBL narrows the theory and practice gap and is a powerful approach (tool) to clinical reasoning and problem solving. According to adult learning theory, certain aspects of the flipped classroom model are conducive to independence and critical thinking.[7] While students read and watch lectures outside of class, they spend class time discussing and solving problems.

In research on modern pedagogical approaches, Sarkar et al discovered that using a blended learning model considerably improved the educational experience for Phase 1 MBBS students. This concept effectively blended integrated content delivery with the usage of digital web technologies. The study found that this strategy effectively motivated student participation in the learning process and actively encouraged a more participatory, dynamic learning environment. Additionally, it was highly helpful in preparing students for self-directed learning, which is an essential ability for medical practitioners. These findings highlight the importance of combining traditional integrated teaching methods with technology to produce more competent and prepared medical graduates. [8]

Using the Kirkpatrick model, Ragsdale et al. proposed a complete methodology for assessing undergraduate clinical instruction. Their central argument emphasizes that a comprehensive evaluation must go beyond simple feedback and include three critical dimensions: baseline measurements to establish a starting point, process indicators to monitor program implementation and delivery, and, most importantly, outcome measures. This approach evaluation is not limited to learner satisfaction (Level 1) or knowledge acquisition (Level 2), but also systematically evaluates the application of learned skills in clinical settings (Level 3: Behavior) and, ultimately, the program's impact on the healthcare system. The goal and central focus of their plan is to establish whether the educational program leads to improved patient care outcomes (Level 4: Results), hence proving its value and effectiveness.[9] Johonson et al. proposed a considerable augmentation of the standard Kirkpatrick assessment model to address the challenges of modern medical education. Their revised framework, based on the New World Kirkpatrick Model, includes new evaluation tiers. These new levels are intended to go beyond analyzing individual student results and instead examine the broader, systemic repercussions of educational systems. The improved technique seeks to analyze the broader effects of public and population health curriculum on the healthcare system and, more importantly, the health outcomes of entire communities. This approach contends that the true worth of medical education should be judged not only by student achievement, but also by its final impact on population health and healthcare systems. [10]

New approaches are now accumulating evidence from all over the world. Student-centered and interactive methods yield better engagement, motivation, and long-term subject retention than more passive approaches to instruction, such as didactic lectures.[11] Furthermore, they align with the principles of competency-based medical education, which emphasize that problem-solving and critical thinking skills, as well as communication skills, should be developed in conjunction with factual knowledge. However, for teachers, these approaches provide the opportunity to become facilitators instead of transmitters of information, allowing for more mentoring and co-creation of knowledge.[12] Despite the demonstrated benefits of innovative strategies/techniques, their implementation faces many persistent challenges. A primary obstacle is faculty development, as educators require training to transition from conventional lecturing to facilitative and interactive teaching roles. Time pressure presents another significant barrier, as designing and executing integrated sessions demands significant curricular planning and coordination among departments. Resource availability, such as access to digital tools, simulation equipment, and updated learning materials, can also limit practical

applications. Finally, student adaptation to new learning styles poses a difficulty, as learners accustomed to passive, lecture-based instructions may initially resist active, self-directed approaches. These interrelated factors, pedagogical readiness, logistical constraints, institutional support, and learner mindset collectively hinder the seamless integration of modern educational methods into curricula.

In the field of Biochemistry, where students often struggle to relate theoretical knowledge to its clinical significance, it becomes even more crucial to employ innovative teaching methods.[13] First, learner insights into these approaches provide a valuable source of feedback for curriculum designers and faculty to improve instructional practices, address student concerns, and ultimately enhance student learning outcomes.[14] Also important is the addition of faculty's viewpoints, as their acceptance and effective implementation of such methods directly affects their success.

This study, therefore, is designed to examine both student and teacher perceptions of innovative teaching mechanisms contained in the integrated modular Biochemistry curriculum.[15] Through the lens of learner insights, the research explores what works, what doesn't, and the overall impact of these approaches on knowledge acquisition, critical thinking, and engagement. The results will contribute to the ongoing improvement of medical education quality and ensure that educational methods are appropriately aligned with evolving learner and healthcare system needs.

METHODOLOGY

The present cross-sectional study was conducted at the University Medical & Dental College, a constituent institution of the University of Faisalabad, where an integrated modular curriculum was implemented in 2025. Ethical approval was obtained from the Institutional Review Board of the University of Faisalabad on January 13, 2025, before commencing the work. The study population consisted of students in the 1st and 2nd year of the MBBS program, following the modular integrated curriculum (version 1 and 2), and teaching staff from the multicentric departments of Biochemistry who taught the subject were included in the study. Students who provided informed consent were included in the study. Students who declined to participate in the study were excluded from the study.[2]

The study was conducted over a period of two months, from January 15, 2025, to March 15, 2025. ERC issued was TUF/IRB/06/25. The sample size was determined using the WHO sample size calculator, and participants were recruited through a simple random sampling method to ensure adequate representation.[16] Quantitative data were collected by using a structured questionnaire-based proforma with Likert scale items to achieve quantitative responses and open-ended questions to gather feedback.

All individuals were provided written informed consent, and confidentiality was strictly enforced by ensuring that participant identities were not revealed. The questionnaire was distributed to students and faculty members to collect their opinions on the integrated modular curriculum and its impact on the teaching and learning of biochemistry, in particular.

Descriptive statistics were used to analyze the quantitative data in SPSS version 22, and closed-ended questions were used to analyze the qualitative responses, identifying emergent themes. This two-prong approach enabled the researcher to gain a thorough sense of student and teacher viewpoints regarding the newly implemented curriculum.[17]

RESULTS

In total, 47.3% of the 300 participants indicated that they agreed, and 12% indicated that they strongly agreed, whereas 8.7% indicated that they disagreed, and 3% indicated that they strongly disagreed, on the integrated modular curriculum. 29% were neutral. Given the overall results, most students were positive, with almost 60% agreeing, showing overall acceptance of the curriculum as mentioned in Figure 1.

Table 1 compares student perceptions of tutorials/SGDs and flipped classrooms in Biochemistry. Mostly (70%), either agreed or strongly agreed that tutorials/SGDs promote a student-centred approach, while only about 48% responded positively to flipped classrooms. Neutral responses were higher for flipped classrooms (36.7%) compared tutorials/SGDs (22.3%), suggesting uncertainty or adjustment issues. A small proportion of students disagreed or strongly disagreed with both methods, though disagreement was more pronounced for flipped classrooms (15.3%) than tutorials/SGDs (7.7). Overall, tutorials/SGds were more favorably received than flipped classrooms. Among the 300 participants, 48% agreed and 16.3% strongly agreed that the case-based learning in Biochemistry was challenging and thought-provoking. In contrast, 11.7% disagreed, 2.3% strongly disagreed and 21.7% were neutral, indicating overall positive perceptions as shown in Figure 2

Table 2 shows associations between learners' groups (students vs. teachers) and their perceptions of different innovative teaching strategies. Across all strategies, teachers expressed more positive responses than students. Significant associations ($p<0.05$) were seen in all four methods, with the strongest agreement among teachers for tutorials/SGDs and large group interactive sessions.

DISCUSSION

Biochemistry is a fundamental discipline that elucidates the metabolic pathways and biological functions of important macromolecules, such as nucleic acids, proteins, carbohydrates, and lipids. It provides a molecular framework for understanding how these biomolecules drive cellular processes, support structural integrity, facilitate energy production, and allow genetic expression. By examining interactions at the molecular level, biochemistry bridges the

Figure 1: Large group interactive sessions in Biochemistry help in the improvement of knowledge?

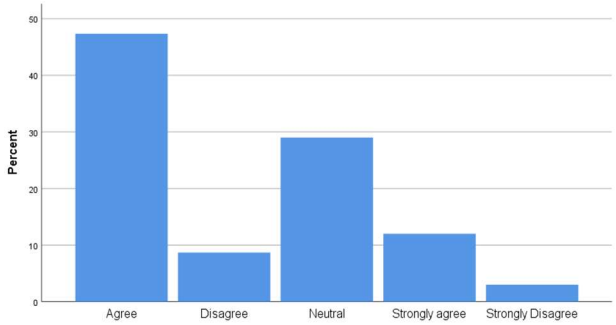
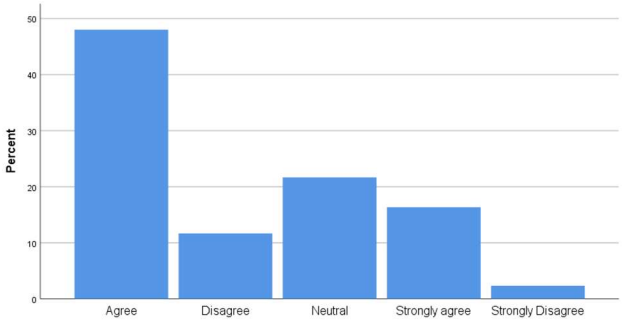


Table 1: Combined Table: Perceptions of Tutorials/SGDs and Flipped Classrooms in Biochemistry

Response	Tutorials/SGDs Frequency (%)	Flipped Classrooms Frequency (%)
Strongly Agree	45 (15.0%)	31 (10.3%)
Agree	165 (55.0%)	113 (37.7%)
Neutral	67 (22.3%)	110 (36.7%)
Disagree	17 (5.7%)	30 (10.0%)
Strongly Disagree	6 (2.0%)	16 (5.3%)
Total	300 (100%)	300 (100%)

Figure 2: Case based learning in Biochemistry IS challenging and thought provoking



gap between basic chemical principles and complex biological systems. However, biochemistry is often regarded as a specific, challenging field. This is largely due to its heavy reliance on abstract concepts like enzyme kinetics, metabolic regulation, and signal transduction pathways, which are not always visually intuitive or directly observable. Furthermore, the subject involves intricate and interconnected metabolic processes that need the integration of vast amounts of information. Unlike more descriptive or concrete disciplines, biochemistry demands a high level of conceptual thinking and the ability to visualise dynamic molecular interactions, making it difficult for many learners to comprehend and retain. Its inherent complexity underscores the importance of effective teaching strategies to make the subject more accessible and engaging. [18]

In the study, Gupta et al.[2] demonstrated high levels of student satisfaction with the integrated teaching-learning strategy. A significant majority of study participants rated the sessions as good, better, or outstanding, especially emphasising their positive impact on engagement, perceived utility, and motivation for lifelong learning. Supporting this learner-centred approach, the work of Debnath et al. underscored the important role of structured, two-way feedback mechanisms. Their research found that such systems were highly effective for refining instructional methods and motivating student involvement, with nearly all students in their study expressing strong approval for these targeted teaching improvement initiatives. Together, these studies affirm the value of interactive and responsive educational strategies in medical curricula.[19]

The findings of our study indicate a generally favorable reception of the integrated modular curriculum in Biochemistry, with approximately 60% of students expressing agreement or strong agreement. This suggests that the curriculum is perceived positively and has been accepted

Table 2: Perceptions of Teaching Strategies in Biochemistry (n=352)

Teaching Strategy	**Group**	**Positive (Agree + Strongly Agree)**	**Negative/Neutral (Neutral + Disagree + Strongly Disagree)**	**Total**	**p-value**
Large Group Interactive Sessions	Students	178	122	300	0.002
	Teachers	42	10	52	
	Total	220	132	352	
Tutorials/SGDs	Students	210	90	300	0.001
	Teachers	44	8	52	
	Total	254	98	352	
Case-Based Learning (CBL)	Students	193	107	300	0.001
	Teachers	31	21	52	
	Total	224	128	352	
Flipped Classroom	Students	144	156	300	0.018
	Teachers	34	18	52	
	Total	178	174	352	

by the majority of learners. The modular approach appears to enhance student engagement, promote deeper understanding, and align well with principles of learner-centred education. However, the notable proportion of neutral responses (29%) highlights that a significant proportion of students may remain uncertain or uncommitted. This underscores the potential requirement for additional orientation, structured support, or clearer communication to facilitate a smoother transition and foster more widespread confidence in the innovative pedagogical approach, as shown in Figure 1. In another study, it was found that 61% students perceived the traditional curriculum to emphasize rote learning and half of them responded that teachers were not trained to deliver an integrated curriculum.[20] Furthermore, according to recent studies, the modular integration concept is one of the potential factors to be considered for enhancing the retention of knowledge and critical thinking skills, supporting the validity of this new training approach in medical education.[21] According to our study**,** findings have shown that 70% of respondents agreed or strongly agreed, indicating a high level of acceptance of the integrated modular curriculum in Biochemistry. Based on these positive perceptions, new training approaches, such as small-group discussions and student-centred approaches, are effective means of enhancing learning experiences. The relatively minimal amount (7.7%) of disagreement further underscores devastating support (from students and faculty). Neutral responses (22.3%) represent transitional difficulties in adapting to new methods. However, recent studies recently demonstrated that modular curricula lead to a significant increase in learner satisfaction and participation in comparison to traditional teaching.[22] Researchers also assessed the superiority of the integrated approach over the isolated approaches in terms of clinical relevance and active engagement, further strengthening the need for the use of modular systems in medical education.[23] The findings show that approximately two-thirds of respondents (64.3%) rated CBL in Biochemistry as challenging and thought-provoking, affirming the value of CBL as a stimulus for higher-order thinking. Based on the small percentage of disagreement (14%), most learners appreciate CBL as an effective method for developing critical reasoning and applying knowledge. Neutral responses (21.7%) can be considered a sign of adjustment to active learning techniques as mentioned in Figure 2. In this regard, findings concluded that CBL improves the problem-solving and clinical reasoning skills of the medical students.[24] Furthermore, researchers stated that CBL can enhance learning on a deeper level and improve learner engagement, as it facilitates the integration of theoretical and practical knowledge. These results demonstrate that CBL is a key element in modular medical curricula.[25]

According to our study, the results showed that almost half of the respondents (48%) viewed the flipped classroom in Biochemistry as a practical innovation, whereas only 15.3% disagreed. Still, a significant fraction (36.7%) was neutral; this suggests that, while many participants valued the advantages of such an approach, others may not have been fully adjusted to its requirements yet. This ambivalent response is consistent with others, where it has been found that flipped classrooms encourage active participation but require a significant amount of learner preparation. For example, different studies found that flipped learning helped improve conceptual understanding and engagement in the classroom for medical education.[26] Similarly, scientists emphasized that while flipped classrooms can improve self-directed learning, they only work when they are well-planned and when learners are flexible.[27]

CONCLUSION

The general findings of this study indicate a generally positive perception of innovative teaching strategies in the integrated modular Biochemistry curriculum. Regarding various teaching methods, most students and faculty expressed agreement or strong agreement with case-based learning, small-group discussions, interactive sessions, and the flipped classroom. Case-based learning was generally described as challenging and thought-provoking, suggesting that it was effective at eliciting higher-order cognitive engagement. Furthermore, tutorial and interactive sessions seemed to be well received, making the learning student-centered a move away from the traditional didactic approach. Although nearly half of this group responded positively about the flipped classroom, there was also a relatively higher percentage of neutral respondents, indicating a need for further definition and support to maximize the effectiveness of this teaching approach. Overall, more than 70% of respondents provided positive responses to the acceptance questions, and these results provide evidence in support of implementing the integrated modular curriculum in medical education. However, the multiple levels of neutrality and disagreement underscore the importance of continuously measuring and adjusting to challenges related to learner preparation, resource availability, and teaching support. By taking student and faculty responses into account, institutions could do more to support these innovative practices, which, over time, would lead to greater knowledge acquisition, critical thinking, and long-term retention in the study of Biochemistry.

LIMITATIONS

Despite the useful insights provided by this study, a few limitations must be considered. First, the cross-sectional approach provides a snapshot of perceptions at a single point in time, making it difficult to analyze the integrated modular curriculum's long-term influence on knowledge retention and academic performance. The reliance on self-reported data from a structured questionnaire raises the possibility of social desirability bias, in which individuals submit

responses they thought were positive rather than their true perceptions. Additionally, the study was conducted at a single medical institution, which, while providing a controlled setting, limits the findings' applicability to other medical schools with varying resources, faculty competence, and student demographics. The sample, while calculated, may not entirely represent the whole population, and the viewpoints of students who did not participate are unknown, potentially skewing the results. The quantitative aspect of the primary data, while useful for quantifying frequencies and associations, provides limited insight into the nuanced reasons behind neutral responses, especially in the context of flipped classrooms. A mixed-methods approach, including qualitative interviews or focus group discussions would have been useful in evaluating the basic causes of ambivalence as well as the specific issues experienced by students and faculty.

Finally, the study failed to account for potential confounding variables such as previous academic performance, previous exposure to traditional teaching methods, or individual faculty members' specific teaching skills, all of which could influence a participant's perception of the new curriculum's effectiveness.

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