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Student Perceptions on the Effectiveness of Alignment and Integration of Topics (AITO) in the Competency-Based Medical Education (CBME) Curriculum: A Cross-Sectional Mixed-Method Study

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ABSTRACT

Background: Competency-Based Medical Education (CBME) incorporates the alignment and integration of related topics (AITO) across basic and clinical sciences to enhance learning. However, limited studies have assessed undergraduate medical students' perceptions about AITO within Indian CBME contexts.
Aim: To evaluate student perceptions regarding the effectiveness and implementation of AITO in the current CBME curriculum using a mixed-method approach.
Methods: A cross-sectional study was conducted with 750 undergraduate students responding to a structured online questionnaire assessing AITO effectiveness across multiple domains. Additionally, four focus group discussions (FGDs) with purposively selected students explored qualitative experiences and challenges. Quantitative data were analysed descriptively and with ANOVA; qualitative data were thematically analysed.
Results: Most students perceived AITO positively, with 78.8% acknowledging its institutional implementation and 76.8% agreeing that integration improved understanding. Two-thirds reported enhanced exam performance linked to AITO. Timetable structure and teaching methods were rated favourably. FGDs revealed themes highlighting enhanced conceptual clarity, systemic barriers (timetable conflicts, faculty coordination), preference for interactive teaching methods, and interest in technological tools for integration support.
Conclusion: AITO is broadly valued by students for improving conceptual integration and clinical application within CBME. Addressing operational barriers and adopting innovative, interactive pedagogies can further enhance its effectiveness. Student feedback should guide continuous curriculum refinement.

Key Words: *Competency-Based Medical Education, Alignment and Integration of Topics, Mixed-Method Study, Students Perception.*

INTRODUCTION

Competency-based medical education, or CBME, is a new technique for matching medical education with the competencies required for efficient clinical practice that has achieved international acclaim. Compared to traditional time-based training models, CBME emphasizes outcomes, learner-centeredness, and the integration of knowledge, skills, and attitudes [1]. The alignment and integration of topics (AITO), which seeks to convey linked concepts across basic sciences and clinical fields in a coordinated manner, is an important pedagogical component of CBME. This integration facilitates the application of theoretical knowledge in practical clinical settings, improves retention, and fosters a comprehensive understanding [2].

Despite its widespread use, implementing AITO involves numerous challenges, including departmental cooperation, effective scheduling alignment, and the selection of appropriate instructional methodologies. Although the theoretical benefits of integrated curricula have been demonstrated in a number of studies, little research has been conducted to investigate students' actual experiences and views of AITO in practical CBME programs. Understanding student views is critical because students are direct stakeholders in educational reform; their insights can reveal practical hurdles, pedagogical gaps, and areas for improvement [3]. Previous researches suggest that effective subject integration generates deeper cognitive connections, improves exam performance, and increases engagement. However, contextual elements such as faculty collaboration, institutional support, and the utilization of cutting-edge instructional tools all have an impact on integration programs' effectiveness. Furthermore, because CBME cohorts are dynamic and diverse, curricular initiatives must be constantly assessed to ensure that they continue to suit the changing needs of learners [4].

This study aims to fill a knowledge gap by evaluating undergraduate medical students' perspectives on the efficacy and integration of AITO into the current CBME curriculum at a tertiary medical institution in India. Using a mixed-methods approach, the study seeks to provide practical recommendations for improving integrated teaching practices by collecting both deep qualitative insights and broad quantitative patterns. This study was intended to provide meaningful data that will assist curriculum designers, instructors, and legislators in optimizing CBME delivery and, ultimately, improving medical education outcomes.

Objective: To assess the perceived usefulness and effectiveness of alignment and integration of topics (AITO) among undergraduate medical students within the current CBME curriculum, using a cross-sectional mixed-method approach combining quantitative survey data and qualitative focus group discussions.

METHODOLOGY:

The opinions of undergraduate medical students regarding the AITO in the Competency-Based Medical Education (CBME) curriculum were assessed using a cross-sectional mixed-methods methodology that used quantitative and qualitative research techniques. In the qualitative component, extensive information was gathered through focus group discussions (FGDs), whereas in the quantitative component, a structured survey was used. The investigation was conducted at Swamy Vivekananda Medical College, Tiruchengode. Undergraduate medical students enrolled in the CBME program from Phase I to the CRRI internship were eligible participants. Both study components were voluntary. To ensure diverse representation across academic stages and demographics, universal sampling was used to choose FGD participants. 750 students, or the whole undergraduate class, completed the quantitative survey. To collect qualitative data from various academic stages, four focus group discussions (FGDs) with ten students each were conducted.

Data Collection tools:

Quantitative component:

The effectiveness, impact on comprehension, exam performance, scheduling, clinical application, teaching methods, and overall learning of AITO were assessed using an 8-item questionnaire with a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). The questionnaire was digitalized using Google Forms to make it easy to collect data without using paper. Because the survey link was distributed electronically, students were able to complete it on their own time with electronic devices. By automating data gathering into Google Sheets, Google Forms made data extraction easier and reduced entry errors. Open-ended questions about students' experiences with AITO, its benefits and drawbacks, preferred methods of instruction, and suggestions for improving curriculum integration were incorporated into the semi-structured guide.

Qualitative component:

Eligible students were given access to a Google Forms link that included informed consent information. Anonymity and secrecy were emphasized in order to encourage honest responses. FGDs lasted between 60 and 90 minutes and were held in private rooms on campus. Sessions were guided by trained moderators with experience in medical education research, while note-takers documented group dynamics and nonverbal signs. Only after receiving the participants' written informed consent were audio recordings made. At first, ground rules were established to facilitate civil and open communication.

Focus Group Discussion (FGD) Details:

Ten students in each group were carefully chosen as FGD participants based on survey willingness, academic phase, and diversity criteria. The semi-structured guide, which addressed everything from preferred teaching styles and recommendations for development to AITO's perceived efficacy and obstacles, was pilot-tested to ensure clarity and relevancy. Moderators guided discussions to delve into specific experiences while also creating a safe space for sharing. Confidentiality guarantees and an agreement to recording were reaffirmed. Before conducting thematic content analysis using pre-existing frameworks, recordings were anonymized and verbatim transcribed. Iterative coding and topic development were employed, and representative quotes were selected to demonstrate the findings.

STATISTICAL ANALYSIS:
Statistical software was used to examine quantitative responses obtained from Google Sheets. Overall trends were summarized using descriptive statistics. Tukey's HSD was used for post-hoc comparisons, and a one-way ANOVA was employed to assess for changes among academic stages. Thematic analysis was used on qualitative data to identify repeating themes and subtle observations, using Braun and Clarke's six-step process [5,6].

Ethical Considerations:
The Institutional Ethics Committee accorded ethical approval. Written informed consent was obtained digitally for the survey via Google Forms, whereas it was obtained in writing for focus group talks. Participation was completely optional, with privacy and data security protections in place.

RESULTS:
750 undergraduate medical students completed a quantitative survey that included all levels of the Competency-Based Medical Education (CBME) curriculum, from Phase I to the CRRI internship. The balanced distribution of the sample across academic years ensured diverse perspectives on AITO.

Quantitative Findings:
The majority of respondents to survey questions expressed positive views on the use of AITO (Table 1). On a 5-point Likert scale, 78.8% of students agreed or strongly agreed with the institute's implementation of AITO. On a 5-point Likert scale, 78.8% of students agreed or strongly agreed with the institute's implementation of AITO. Similarly, 77.5% of participants rated integration effectiveness across subjects/modules as positive. 76.8% of students stated that integrated teaching increased their understanding of the content when compared to traditional solo lectures. Approximately 66.7% of respondents reported that topic alignment and integration enhanced their exam scores. A well-structured schedule was regarded by 79 percent of respondents as a means of linking themes.

Table 1: Student Perceptions of AITO Implementation and Effectiveness (N=750)

Q. No	Survey Item	Mean Score (± SD)	% Agree / Strongly Agree
1	AITO is followed in our institute	4.1 ± 0.8	78.8
2	Integration effective across subjects / modules	4.0 ± 0.9	77.5
3	Integration helped better understanding compared to individual lectures	3.9 ± 0.9	76.8
4	Alignment and integration improved exam performance	3.8 ± 1.0	66.7
5	Well-structured timetable aided topic connection	3.9 ± 0.9	70.9
6	Aligned topics enhanced ability to apply knowledge clinically	4.0 ± 0.9	74.8
7	Teaching methods for delivering integrated topics were effective	3.9 ± 0.9	73.1
8	AITO improved overall learning experience	3.9 ± 0.9	73.8

Table 2: Comparison of mean scores between phases of students by ANOVA (N = 750)

Q. No.	Item	Mean	S. D	Mean Square	F	p value
1	AITO (alignment and integration of topics) is followed in our institute.	3.92	0.976	0.988	1.037	0.387
2	AITO topics are integrated across different subjects/modules	3.87	0.954	0.939	1.032	0.39
3	Integration helped you understand overall subject better	3.89	0.963	1.428	1.544	0.188
4	Performed better on exams thanks to alignment/integration	3.71	0.99	2.709	2.788	0.026
5	Well-structured schedule timetable made it easier to connect topics	3.79	0.989	1.705	1.75	0.137
6	Enhanced ability to apply theory in clinical scenarios	3.85	0.973	1.945	2.067	0.083
7	Teaching methods for aligned/integrated topics were effective	3.81	0.972	1.209	1.281	0.276
8	Alignment/integration in curriculum improved overall learning experience	3.82	0.95	2.008	2.242	0.063

Furthermore, 74.8% of respondents thought that AITO enhanced their ability to apply theoretical knowledge in practical contexts. 73.1% of respondents found the teaching tactics utilized to deliver integrated subjects successful. Overall, 73.8% of students reported

that the topic alignment and integration improved their overall learning experience. Senior students (Phase III & Interns) reported greater benefits from AITO, with significant variations in exam performance increases observed across academic phases (one-way ANOVA, p = 0.0256) (Table 2).

In terms of grading perceptions, 26% scored it completely satisfied, while 47% chose the medium group, indicating moderate satisfaction (Table 3). Furthermore, 85.2% of respondents expressed an openness to curricular revisions, stating that integrated and aligned subjects may be developed further to increase learning. There was clearly a high level of respondent participation, with 91.7% adding additional observations or recommendations (Table 4).

Figure 3: Grading of Perception based on scoring among students (N = 750)

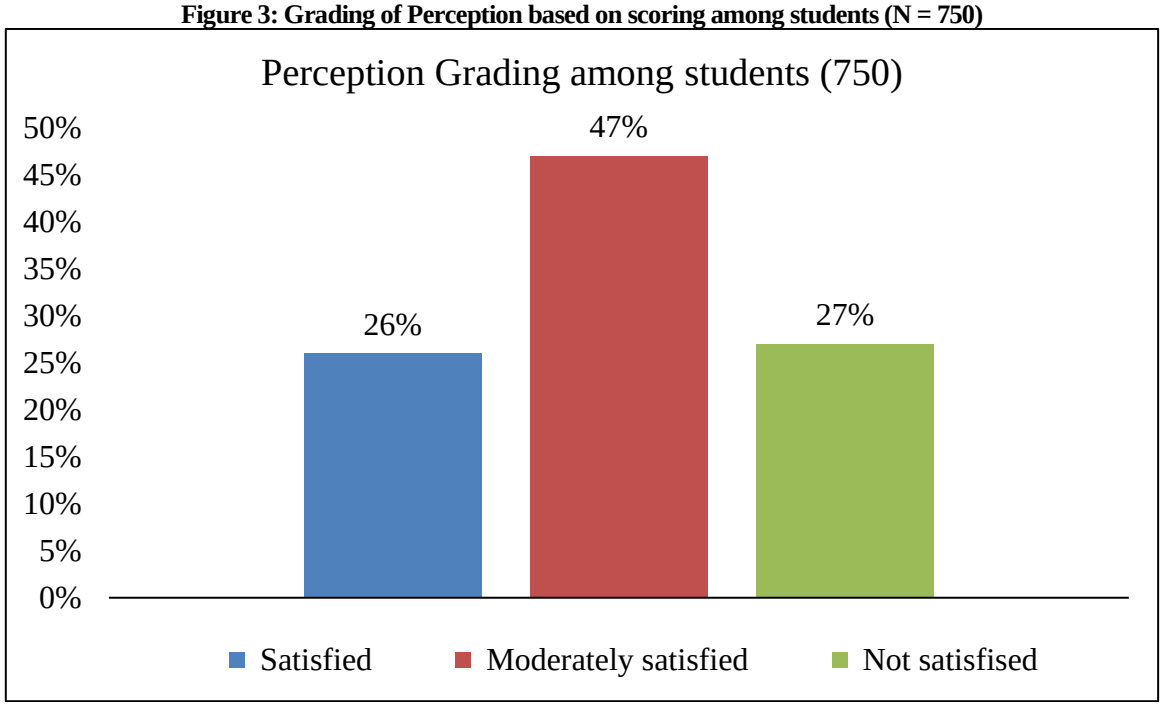


Table 4. Student Suggestions and Grading Perceptions (N=750)

Item	Frequency (%)
Scope for further improvement of aligned topics	85.2
Additional comments or suggestions provided	91.7
Perception of grading system (Positive or Neutral)	74.4

Qualitative Findings from Focus Group Conversations:
Braun and Clarke's six-step thematic framework of analysis applied to the AITO-CBME FGD recordings and divided into 6 themes as follows:

Theme 1: Appreciation of Conceptual Clarity via Integration
This theme captures student recognition of how the alignment and integration of topics enhance their understanding and retention by linking related concepts across subjects. Codes such as improved conceptual understanding, linking physiology, pathology, and clinical practice, enhanced retention through integrated learning, and examples of cardiovascular, diabetes, obstetrics integration

Illustrative Extract: "Integration helped me understand how different subjects connect, especially in cardiovascular modules where anatomy and clinical cases were taught together." (Phase I)

Theme 2: Systemic Barriers to Effective AITO Delivery
Students identified obstacles in the practical implementation of AITO, including scheduling conflicts, lack of faculty coordination, and increased workload without adequate consolidation.

Codes are timetable clashes, repetitive content across departments, faculty coordination challenges, heavy workload and contact hours, and inconsistent integration quality

Illustrative Extract: "Sometimes sessions clash in the timetable, and different departments repeat similar content without proper coordination." (Phase III)

Theme 3: Impact on Learning Outcomes and Exams
This theme explores students' perceptions of how AITO influences their academic performance and motivation related to exams and evaluations. Codes are improved exam performance with integrated topics, motivation linked to exam coverage, variability in exam alignment across sessions, and case discussions aiding clinical exam preparation

Illustrative Extract: *"When the integrated topics were directly linked to our exams, it helped me prepare better, especially in clinical case discussions."* (Phase IV)

Theme 4: Preferences for Interactive and Practical Teaching Methods
Students expressed preferences for teaching strategies that foster active learning, such as case-based discussions, small groups, and simulation, over didactic lectures. Codes such as case-based learning (CBL), small group interactive sessions, simulation and skill labs, team teaching by multiple faculties, and less reliance on PowerPoint lectures

Illustrative Extract: *"Small groups and case-based discussions really helped me grasp the integrated topics better than lectures."* (Phase II)

Theme 5: Role of Technology in Enhancing AITO
This theme addresses student suggestions on utilizing digital tools and AI to support and improve the process of topic integration. The codes are digital platform for multimedia modules, AI-driven personalized quizzes, recorded lectures for flexible review, technology to map competencies to topics

Illustrative Extract: *"Having AI-based quizzes tailored to integrated topics would improve retention and help us identify weak areas."* (Phase II)

Theme 6: Recommendations for Curriculum Improvement
Suggestions by students on how to enhance AITO through better planning, coordination, and teaching innovations. The codes were better interdepartmental coordination and planning, mapping integration with competency and exams, increased use of simulation and bedside teaching, formation of integration committees, and continuous student feedback mechanisms

Illustrative Extract: *"We need committees to coordinate AITO delivery and ensure sessions are complementary, not repetitive."* (Phase III)

Table 2: Coding Framework of FGD (N = 750)

Theme	Codes
Appreciation of Conceptual Clarity	Concept linking, retention, integrated examples (cardiology, diabetes, OBG)
Systemic Barriers to Effective Delivery	Timetable issues, faculty coordination, workload, repeated content
Impact on Learning Outcomes and Exams	Exam performance, motivation, case discussions, exam alignment
Preferences for Interactive Teaching	Case-based learning, small groups, simulation, team teaching, reduced didactic lectures
Role of Technology	Digital modules, AI quizzes, recorded lectures, competency mapping
Recommendations for Curriculum Improvement	Coordination, planning, exam mapping, simulation, integration committee, student feedback

Thematic content analysis of four focus groups (N = 40) revealed six significant themes about students' experiences with AITO:

1. **Enhanced Conceptual Clarity:** Students consistently highlighted that integration helped connect basic and clinical sciences, improving understanding and retention across subjects such as cardiovascular physiology and diabetes modules.
2. **Systemic Barriers:** Scheduling conflicts, poor faculty coordination, and content redundancy emerged as significant obstacles to effective AITO implementation. Students noted frequent timetable clashes and repeated content delivery in some cases.
3. **Impact on Learning and Exam Performance:** Integration was reported to enhance exam readiness, particularly when linked directly to evaluation content. However, inconsistent alignment with summative assessments sometimes reduced motivation.
4. **Preferred Interactive Teaching Methods:** Participants favoured small group activities, case-based discussions, simulation, and team-teaching over didactic lectures. These methods were perceived to facilitate deeper engagement with integrated topics.

5. **Role of Technology:** Students advocated for digital resources such as AI-driven quizzes, multimedia modules, and recorded lectures to augment integration and personalized learning.
6. **Recommendations for Improvement:** Suggestions included better interdepartmental coordination, formation of integration committees, improved timetable planning, and expanded use of interactive and clinical teaching modalities.

FGD findings

The qualitative thematic analysis of focus group discussions with undergraduate medical students across four phases revealed multifaceted perceptions of the Alignment and Integration of Topics (AITO) within the CBME curriculum. Students broadly valued AITO for enhancing conceptual clarity and linking basic sciences to clinical practice, which aided understanding and retention. AITO was perceived to improve application of knowledge in clinical scenarios and support exam preparation when integration was explicitly aligned with assessments. However, systemic barriers including timetable conflicts, inadequate faculty coordination, and repetitive content delivery were reported across all phases, limiting the effectiveness of integration efforts. Participants emphasized a preference for interactive, case-based, and simulation-based learning approaches over didactic lectures to make integration meaningful and applicable. Students suggested leveraging digital tools and AI-driven personalized learning to enhance retention and coordinate curriculum delivery better. Recommendations included stronger interdepartmental planning, explicit mapping of integrated topics to competencies and exams, and institutional mechanisms such as integration committees to sustain quality and coordination. This thematic qualitative insight complements quantitative findings by contextualizing the nuanced barriers and facilitators influencing AITO implementation, thus providing a comprehensive understanding to inform curriculum refinement. The integration of these qualitative themes with quantitative data enables triangulation and richer interpretation of AITO's impact in CBME educational outcomes.

DISCUSSION:

This study provides comprehensive insight into undergraduate medical students' perceptions of alignment and integration of topics (AITO) within the Competency-Based Medical Education (CBME) framework at a tertiary medical college in Tamil Nadu. The predominantly positive reception of AITO by students aligns well with global and Indian evidence supporting integrated, competency-based curricula in medical education. Our quantitative findings demonstrated strong student agreement that AITO is effectively implemented (78.8%) and enhances understanding (76.8%), which is in concordance with similar studies in India. For instance, Doraisamy and Radhakrishnan et al. [7] (2022) found that integrated curricular approaches significantly improved students' conceptual grasp and academic performance in Northern Indian medical colleges. These findings reinforce that well-executed integration fosters cohesive learning, bridging the gap between basic sciences and clinical application. The qualitative analysis by Mondal et al. [8] highlighted that students value conceptual clarity derived from integration, consistent with observations from institutions with integrated teaching improved engagement and comprehension among preclinical students. Students attributed improved exam performance to alignment, echoing results from the study in a medical college in Karnataka by Patil et al. [9] (2023) where integrated MCQs enhanced assessment relevance and student motivation. Nonetheless, systemic barriers such as timetable clashes, content duplication, and inadequate faculty collaboration were repeatedly noted. These findings resonate with challenges reported by Bannaravuri et al. [10] (2023) study on CBME implementation in AIIMS Madurai, emphasizing the practical difficulties in synchronizing diverse departmental schedules and harmonizing curricula to avoid overlapping content delivery. Addressing these issues through institutional governance, interdepartmental planning committees, and centralized timetable coordination is critical, as also suggested by the National Medical Commission's guidelines on CBME integration (NMC, 2024) [11]. In the study by Rangareddy et al. [12] found that student preferences for interactive teaching modalities such as small group discussions, simulations, and team-based learning align with national pedagogical trends advocating active learning to enhance critical thinking and clinical reasoning. These findings was also resonated by a randomized crossover study [13]. The study by Quek et al. [14] showed the potential role of technology-enhanced learning—through AI quizzes, virtual cases, and recorded content—was underscored by participants, reflecting a growing recognition of digital tools in India's evolving medical education landscape, especially amid increased post-pandemic adoption. The combination of quantitative and qualitative data in this study provides a nuanced understanding of AITO's strengths and areas needing refinement. While effective in principle and appreciated by students, the operational complexities identified underscore that successful AITO implementation requires robust institutional support, faculty development, and adherence to alignment principles in both content and assessment methods. Comparison with state and national experiences confirms that Tamil Nadu's CBME implementation is progressing on par with best practices yet must continuously adapt to local contexts and stakeholder feedback. Faculty engagement and administrative empowerment remain pillars for advancing integration, as evidenced in multi-institutional research within India by Ramanathan et al. [15] (2021).

LIMITATIONS:

This study is limited by its single-centre design, which may affect the generalizability of findings to other medical colleges with different characteristics. The cross-sectional nature restricts causal inferences or examination of perception changes over time. The qualitative component involved a purposive sample, which, while diverse, may not fully represent all student viewpoints. Additionally, faculty perspectives and long-term outcomes of AITO implementation were not explored and warrant future research.

CONCLUSION:

Alignment and integration of topics within the CBME curriculum are positively perceived by students in Tamil Nadu, enhancing understanding, clinical application, and examination performance. Despite operational challenges such as timetable coordination and

faculty collaboration, the overall impact of AITO on student learning is favourable. Emphasizing improved institutional support, faculty development, and incorporation of interactive and technological teaching methods can further optimize integrated curricula outcomes. Continued multi-institutional evaluation and inclusion of faculty feedback will be essential to refine and sustain these curricular reforms in India.

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