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Original Research Article

Beyond the Traditional Flipped Classroom: Implementing "Just-in-Time Flipping" for Teaching Complex Pharmacology Topics to Undergraduate Medical Students

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Abstract

Introduction: Pharmacology is often perceived as a difficult subject due to its heavy factual content and abstract mechanisms. While traditional flipped classrooms promote active learning, they can increase student workload and suffer from inconsistent pre-class preparation. Just-in-Time Flipping (JiTF) is an innovative modification where preparatory time is provided at the start of the class under faculty supervision. This study aimed to assess the perceptions of Phase II MBBS students regarding the JiTF strategy in teaching the pharmacology of chelating agents and to evaluate their post-class performance.

Methodology: This single-session, cross-sectional educational intervention involved Phase II MBBS students. Using the JiTF approach, students were given 20 minutes at the beginning of the session to review structured materials (PowerPoint slides, infographics, and reference notes) via Google Classroom under faculty supervision. This was followed by 15 minutes of case-based group discussions, class-wide presentations, and 15 minutes of faculty-facilitated interaction to clarify misconceptions. Outcomes were measured using a structured feedback questionnaire to assess student perceptions and a 10-item multiple-choice post-class quiz to evaluate short-term knowledge consolidation.

Results: The session was attended by 115 students, of whom 105 (91.3%) provided feedback. 90.5% of participants rated the JiTF format as better than traditional lectures, with none rating it as worse. A significant majority (96.2%) agreed that case-based discussions helped them apply pharmacological knowledge to clinical contexts, and 91.4% reported feeling actively engaged during the session. In the post-class assessment, the mean score was 6.45 out of 10, with 58.2% of students achieving "Good" or "Excellent" grades. Qualitative feedback highlighted themes of interactive learning improved conceptual clarity, and a strong recommendation (95%) to use this method for other pharmacology topics.

Conclusion: The JiTF approach was well-received and perceived as more effective than traditional lectures for teaching complex pharmacology topics. By integrating supervised self-study and active discussion into a single session, JiTF enhances student engagement and knowledge application overcoming the limitations of conventional flipped classrooms.

Keywords: Pharmacology, Just-in-Time Flipping, Medical Education, Chelating Agents, Active Learning, Flipped Classroom.

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Introduction

Pharmacology is a core subject in undergraduate medical education, bridging the basic sciences and clinical practice. However, students often perceive pharmacology as difficult to learn due to the heavy factual content, abstract mechanisms, and limited clinical context in traditional lectures [1-3]. This difficulty frequently translates into poor retention, lack of engagement, and reduced confidence in applying pharmacological knowledge during clinical years [4].

In recent years, medical education has seen a global shift from passive, teacher-centered learning to

active, learner-centered approaches. Active learning strategies such as team-based learning, case-based discussions, and flipped classrooms have shown significant improvements in student engagement and knowledge outcomes compared to conventional didactic lectures [5,6]. The flipped classroom model, in particular, emphasizes pre-class preparation by students and in-class application of concepts through problem-solving, thereby enhancing critical thinking and deep learning [7].

Although in the pre-class phase, a flipped classroom gives freedom and flexibility to the students to prepare at their own time and their way, the drawback of the same is the extra need for time in pre-class preparation, in which students have to provide extra time for the given topic, which increases their workload. Also, some students do not get engaged in pre-class preparation due to various reasons, largely because the pre-class phase is unobserved by a teacher. [7,8]

In an effort to reduce the mentioned drawbacks of the flipped classroom, a modification of this strategy, "Just-in-Time flipping", has emerged as a promising innovation in health professions education. Here, instead of pre-class preparation, "just-in-time" preparatory time can be allowed to the students in the beginning of the class inside the classroom, in which all needed preparatory materials, such as presentation, video, infographics, and other reading material, can be provided to the students. This can remove the extra time needed at home and reduce the overall workload of the students. It can also allow a teacher to facilitate and guide the students to better engage with the given material, in which students are free to ask the teacher, and the teacher is free to observe students. This dynamic, responsive approach ensures that learners' misconceptions are corrected, and classroom time is used more effectively for higher-order cognitive tasks [9] offering the dual advantage of self-directed pre-class learning and adaptive, interactive in-class sessions [10].

Several studies across the globe have demonstrated that flipped classroom models improve student learning outcomes, motivation, and satisfaction in medical education [11-14]. In India too, early experiences with flipped classrooms in pharmacology and other subjects have shown positive results [15,16]. However, published literature specifically exploring the integration of "Just-in-Time Flipping" in teaching pharmacology to undergraduate medical students remains limited. Apart from student perception, understanding immediate post-session performance may provide complementary insight into learners' short-term knowledge consolidation following such active learning interventions. Moreover, pharmacological topics such as chelating agents are often perceived as complex and less engaging, yet they hold crucial clinical relevance in the management of poisoning, metal toxicity, and other conditions [17].

Given the need for innovative strategies that promote deeper understanding of difficult pharmacology concepts, the study was conducted with the following objectives:

Primary Objective: To assess the perception of Phase II MBBS students regarding the "Just-in-Time Flipping" strategy in teaching the pharmacology of chelating agents.

Secondary Objective: To assess students' post-class performance following the "Just-in-Time Flipping" session using an MCQ-based assessment.

Materials and Methods

Study Design and Setting: This was a single-session, cross-sectional educational intervention conducted in the Department of Pharmacology at Pramukhswami Medical College, Karamsad, Gujarat, in July 2025. The session was part of the regular Phase II MBBS pharmacology teaching schedule. Approval for the study was obtained from the Institutional Ethics Committee (Approval No: IEC/BU/2025/Ex.78/293/2025). A waiver of informed consent was granted because the activity formed part of routine teaching, no additional intervention was carried out, and only anonymized feedback data were analyzed.

The study included all Phase II undergraduate medical students (batch of 2023) who attended the scheduled class on "Pharmacology of Chelating Agents" (Competency Based Undergraduate Curriculum For the Indian Medical Graduate 2018 competency PH 1.53: "Describe heavy metal poisoning and chelating agents") and voluntarily submitted the anonymous feedback form. Since the session was part of the regular curriculum and feedback was anonymized, no exclusion criteria were applied.

The teaching session was conducted using the "Just-in-Time Flipping" (JiTF) approach, which is a modification of the flipped classroom model. At the beginning of the session, students were oriented to the format, and a QR code linking to a Google Classroom (https://classroom.google.com/) was displayed for access to session materials. To activate prior knowledge, a short multiple-choice pre-class quiz was administered. Students were then given 20 minutes of structured preparatory time to review the uploaded pre-read materials, which included PowerPoint slides, an infographic, and concise reference notes on the topic.

Subsequently, students were divided into four groups, and each group was assigned a clinical case scenario with related questions on chelating agents. The groups were allowed 15 minutes for

discussion, after which representatives presented their responses in a class-wide discussion. This was followed by a 15-minute faculty-facilitated interaction that clarified misconceptions and emphasized key pharmacological concepts. At the end of the session, students completed a post-class multiple-choice quiz containing ten items designed to consolidate learning. The post-class quiz results were analyzed descriptively to summarize student performance.

Finally, all participants were invited to provide feedback on the JiTF strategy through a pre-validated, structured questionnaire administered via Google Form. The questionnaire contained eleven items, including seven closed-ended questions rated on Likert scales and four open-ended questions. The items were designed to capture student perceptions regarding session design and content, learning experience, and suggestions for improvement. All study instruments, including quizzes, case scenarios, and the feedback questionnaire, were provided through Google Classroom as class progressed as per requirement.

The primary outcome measure was the perception of students regarding the JiTF strategy as a teaching-learning approach in pharmacology, as assessed through the structured feedback questionnaire. Secondary outcome of assessment of students' performance following the JiTF was fulfilled based on the post class MCQ test.

Data Analysis: Quantitative data from closed-ended items were analyzed using descriptive statistics such as frequency and percentage, and results were summarized in tabular form. Qualitative data from open-ended responses were subjected to thematic analysis, wherein responses were coded and categorized to identify common themes and student suggestions. Data analysis was performed using Microsoft Excel and Jamovi (Jamovi Desktop version 2.6.44). (https://www.jamovi.org/)

Results

Of the 150 students enrolled in Phase II MBBS (batch of 2023), 115 (76.66%) attended the session on Pharmacology of Chelating Agents. Among those 115 students, 105 (91.3%) students completed the feedback form while all 115 have attended post class assessment test. Among the respondents, 52 (49.5%) were male and 53 (50.5%) were female.

Perception on Session Design and Content: Most students found the pre-class materials useful. Forty-two (40.0%) rated them as 'very useful' and 23 (21.9%) as 'useful'. The mean rating score was 2.31 ± 1.26 on a 5-point scale (1 = Very useful, 5 = Not useful). The clarity of the topic was rated positively by the majority of students. Seventy-three (69.5%) reported that chelating agents were 'clearly explained', 30 (28.6%) found it 'somewhat clear', and only 2 (1.9%) considered it 'confusing'.

None of the respondents felt that the topic was 'not explained properly'. Almost all students perceived that clinical cases enhanced their understanding. Ninety-seven students (96.2%) agreed or strongly agreed that case-based discussions helped them apply pharmacological knowledge to clinical contexts. Table 1 and Figure 1 summarizes students' perceptions of the session design and content.

Table 1: Student feedback on session design and content (n = 105)

Item/ Question	Response categories	n	%
Usefulness of pre-class materials	Very useful	42	40.0
	Useful	23	21.9
	Neutral	16	15.2
	Less useful	13	12.4
	Not useful	11	10.5
Clarity of topic (Chelating agents)	Clearly explained	73	69.5
	Somewhat clear	30	28.6
	Confusing	2	1.9
	Not explained properly	0	0.0
Clinical cases helped apply knowledge	Strongly agree	42	40.0
	Agree	59	56.2
	Neutral	4	3.8
	Disagree	0	0.0
	Strongly disagree	0	0.0

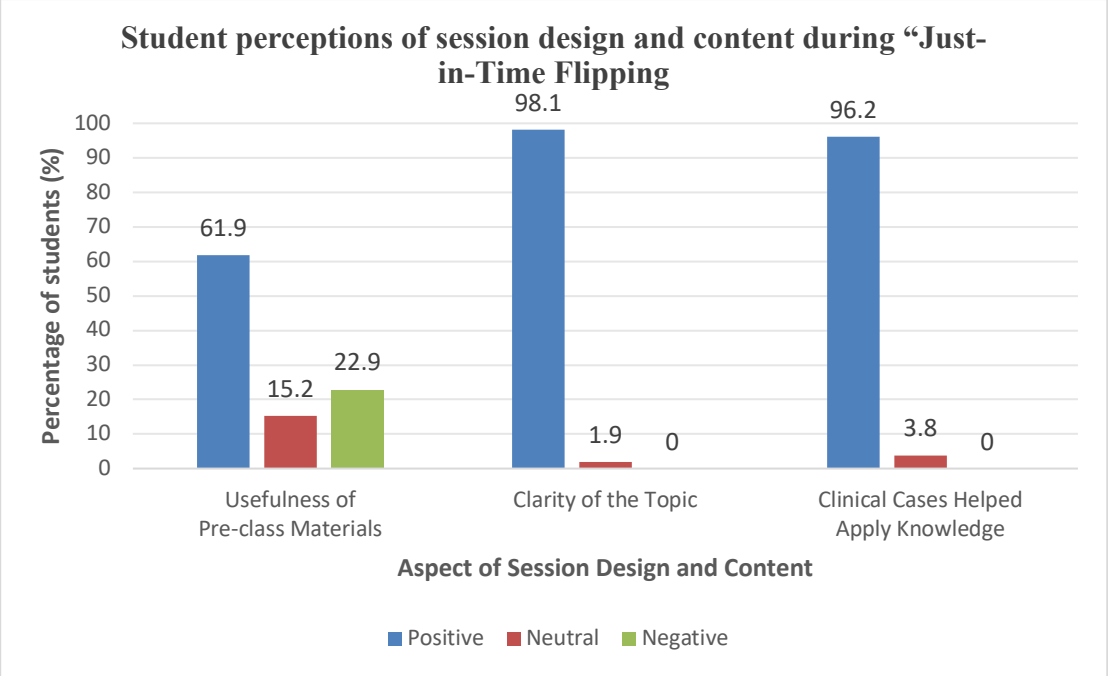

Figure 1: Student perceptions of session design and content during "Just-in-Time Flipping" (n = 105)

Perceptions on Learning Experience: Nearly all students reported a positive learning experience with the "Just-in-Time Flipping" approach (Table 2). Ninety-five (90.5%) perceived this format as better or much better than a traditional lecture, while none rated it as worse (Figure 2). Most participants agreed that active learning components were beneficial — 98 students (93.3%) agreed or strongly agreed that class discussions and group work reinforced their understanding. Similarly, 96 (91.4%) students agreed or strongly agreed that they felt actively engaged during the session. Only one student (1.0%) reported disagreement. Table 2 summarises student perceptions of the learning experience during the "Just-in-Time Flipping" session.

Table 2: Student perception on learning experience (n = 105)

Item/ Question	Response categories	n	%
Compared to a traditional lecture, this flipped format was:	Much better	50	47.6
	Better	45	42.9
	Same	10	9.5
	Worse	0	0.0
Class discussion and group work helped reinforce learning:	Strongly agree	37	35.2
	Agree	61	58.1
	Neutral	7	6.7
	Disagree	0	0.0
	Strongly disagree	0	0.0
I felt actively engaged in the learning process:	Strongly agree	38	36.2
	Agree	58	55.2
	Neutral	8	7.6
	Disagree	1	1.0
	Strongly disagree	0	0.0

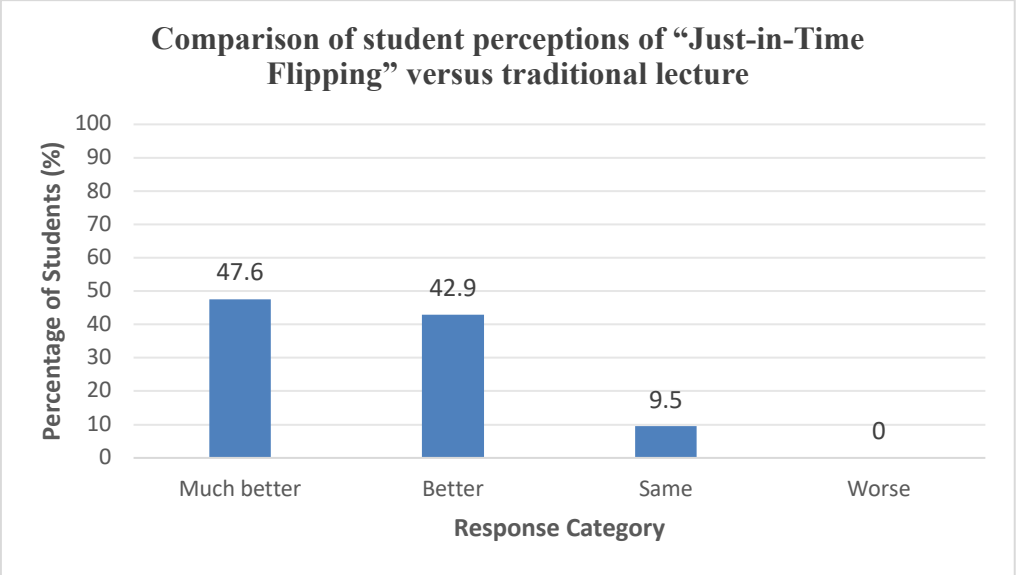

Figure 2: Comparison of student perception of "Just-in-Time-Flipping" with traditional lecture (n = 105)

Open-Ended Feedback: Thematic analysis of open-ended feedback from 105 participants revealed four major themes: (1) interactive and engaging learning environment, (2) self-directed learning and conceptual clarity, (3) time management and structural improvements, and (4) positive recommendation and topic suggestions for future JiTF sessions.

On asking what was liked most about the session, a large number of students appreciated the interactive and engaging nature of the session, emphasising active participation, peer discussion, and case-based learning. They valued the knowledge-application-based group activities facilitated by the teacher. The feedback, like "The group activity helped me to learn better and understand the topic in a practical way," and "It was interesting to discuss cases and think about answers rather than just listen," was received. Students also appreciated the provision of preparatory materials and dedicated self-study time before group discussion. The feedback like "The time given for self-reading helped me understand the concepts properly," and "Pre-class materials were easy to follow and made the discussion more meaningful," was received.

On asking about what can be improved in future sessions, most comments were constructive, focusing on time management and session structure. Several students requested slightly longer periods for self-reading or group discussions, while others suggested having more such sessions in the curriculum. Mainly "More time for discussion would have helped," and "Please conduct such sessions more often," like responses were received. A few participants mentioned logistical aspects such as slide visibility or simplification of reading materials, whereas many indicated that no change was required.

On asking "Would you recommend this method for other pharmacology topics?", nearly all respondents expressed willingness, describing it as effective, engaging, and preferable to routine lectures. "Yes, this method makes learning easier and more interesting," was a common response by the students. Frequently suggested topics included the Autonomic Nervous System, antibiotics, Central Nervous System, toxicology, and ADR management.

The summary of themes from qualitative feedback is shown in table 3.

Table 3: Summary of Themes from Qualitative Feedback (n = 105)

Theme	Sub-theme/ Codes	Representative comments	Frequency
Interactive & engaging learning	Group discussions, peer learning, faculty facilitation	"Interactive and fun to learn together."	45 %
Self-directed learning & conceptual clarity	Independent reading, clarity of concepts, effective preparatory materials	"Self-reading time made me understand better."	20 %
Time management & improvement suggestions	Longer discussion time, more JiTF sessions, logistics	"More time for group activity would help."	40 %
Positive recommendation	Endorsement of JiTF for other topics	"This method should be used for all difficult topics."	95 %
Suggested topics	ANS, antibiotics, CNS, toxicology, ADR management	"Use this method for antibiotics and ANS."	60 %

Post-class Assessment:: Post-class assessment consisted of 10 multiple-choice questions, each carrying one mark (maximum score = 10). All 115 students completed the test. The mean score obtained was 6.45 (64.5%), with a median score of 7 (70%) and a score range of 2 to 9. Student performance was graded using a predefined percentage-based grading categories as excellent (≥90%), good (70–89%), satisfactory (50–69%), and needs improvement (<50%). (Table 4)

Table 4: Distribution of post-class assessment grades

Grade	Number (Out of 115)	Percentage
Excellent (≥90%)	10	8.6%
Good (70–89%)	57	49.57%
Satisfactory (50–69%)	33	28.70%
Needs improvement (<50%)	15	13.04%

Discussion:

The current study investigated how Phase II MBBS students felt about the "Just-in-Time Flipping" (JiTF) method of teaching chelating agent pharmacology. The majority of students perceived JiTF was more effective than traditional lectures. Active engagement and application of pharmacological knowledge seemed to be facilitated by the incorporation of case-based group discussions, in-class self-study time, and organized preparatory materials. These results imply that JiTF is an acceptable active learning approach for teaching Pharmacology to undergraduate students.

In this study, 61.9% of students rated the preparatory materials as very useful or useful, with a mean usefulness score of 2.31 ± 1.26 on a five-point Likert scale. JiTF incorporates the preparatory phase into the classroom under faculty supervision, in contrast to traditional flipped classrooms where pre-class preparation is student-dependent and frequently inconsistent. Previous studies on flipped classroom have stated some of the limitations as inadequate pre-class engagement, increased workload, and lack of accountability [7,10]. Variablility in student preparedness has also been noted when the pre-class learning is unsupervised [18]. JiTF, on the other hand, ensures uniform exposure to learning resources and allows real-time clarification of doubts, thereby enhancing preparedness. Similar advantages have been reported in Just-in-Time Teaching models, where timely access to learning materials combined with instructor facilitation improved learner satisfaction and engagement [9].

A substantial proportion of students in the present study (69.5%) reported that the topic of chelating agents was "clearly explained," while 28.6% found it "somewhat clear," indicating that over 98% perceived adequate conceptual clarity. Chelating agents are often considered difficult due to their abstract mechanisms and limited exposure in clinical teaching [17]. The structured JiTF approach-combining guided self-study, case discussions, and faculty facilitation-likely contributed to improved understanding. Similar improvements in conceptual clarity have been reported with flipped classroom approaches in pharmacology and other medical subjects [7,13,16], suggesting that active engagement and contextual learning play a critical role in mastering complex topics. One of the most notable findings of this study was that 96.2% of students agreed or strongly agreed that clinical case discussions helped them apply pharmacological knowledge to clinical contexts. Higher-order cognitive abilities, such as clinical reasoning and decision-making, are known to be enhanced by case-based learning [5,6]. According to a recent systematic review and meta-analysis, flipped classrooms when combined with case-based instruction, show improved application of knowledge, clinical reasoning, and learner satisfaction as compared to lecture-based methods alone (19). In the current study, the integration of case scenarios within the JiTF framework allowed students to immediately apply newly acquired knowledge, reinforcing learning through peer discussion and faculty feedback. This finding is in line with past research on pharmacology flipped classrooms, where case-based discussions greatly increased student engagement and knowledge application [10,16].

With 93.3% agreeing or strongly agreeing that group discussions reinforced learning and 91.4% reporting active engagement during the session, the JiTF session was linked to high levels of student engagement in this study. In terms of student engagement and learning outcomes, active learning strategies have repeatedly demonstrated better performance than traditional lectures [5,6]. Similar results have been found in systematic review assessing flipped classrooms in health professional education, showing increased learner satisfaction, motivation, and engagement when active learning replaces passive lectures [20]. The present study adds to this evidence by demonstrating that JiTF, a modified form of flipped learning, can achieve comparable or potentially superior engagement by minimizing the disadvantage of unsupervised pre-class preparation.

The qualitative findings further reinforced the quantitative results. Students frequently highlighted

the interactive and engaging learning environment, self-directed learning with improved conceptual clarity and effective faculty facilitation as strengths of the JiTF approach. Importantly, 95% of students recommended JiTF for other pharmacology topics, particularly for traditionally challenging areas such as autonomic nervous system, antibiotics, and toxicology. Similar qualitative themes have been documented in studies assessing Just-in-Time Teaching and flipped classrooms, where students valued active participation, flexibility, and relevance to clinical practice [9,11,15]. Student acceptance of the approach is understood by the constructive suggestions pertaining to time management and increasing the frequency of these sessions, which show positive engagement rather than dissatisfaction.

The post-class assessment demonstrated that a majority of students achieved satisfactory to good performance, suggesting that the JiTF session provided an adequate learning environment for short-term knowledge consolidation.

The findings of this study suggest that JiTF is a feasible and effective strategy for undergraduate pharmacology teaching. By combining supervised self-study, active discussion, and faculty guidance within a single session, JiTF addresses key limitations of both traditional lectures and conventional flipped classrooms. Given the positive student perceptions and high levels of engagement observed, JiTF may be particularly suitable for clinically relevant topics of pharmacology.

Strengths and limitations: A key strength of this study is the comprehensive evaluation of student perception using both quantitative and qualitative methods.

However, the study was limited to a single session and relied on self-reported perceptions rather than objective learning outcomes. Future studies incorporating pretest and post-test assessments and multi-session interventions or having a control group could provide further insights into the long-term educational impact of JiTF.

Conclusion

In conclusion, the Just-in-Time Flipping (JiTF) approach was well received by Phase II MBBS students and was perceived as more effective than traditional lectures for learning pharmacology. The strategy enhanced engagement, conceptual clarity, and application of knowledge, with students demonstrating satisfactory post-session performance. It suggests that JiTF may serve as a valuable addition to traditional teaching methodologies for pharmacology.

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