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Evaluation of Integrated-Shared Teaching Within-Class Activity for Basic Science Medical Students

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ABSTRACT

Background

A study at Xavier University School of Medicine introduced an integrated-shared teaching model to address the challenges of medical education. This new approach combines physiology, biochemistry, and pathology into single, organ-system-based sessions, aiming to reduce content redundancy and promote a holistic understanding. This integrated model uses cognitive learning theory to improve retention. By linking subjects like physiology and pathology, it helps students form interconnected mental frameworks called schemata. This reduces cognitive load, moving beyond simple memorization to a deeper, more meaningful understanding that's easier to apply in clinical practice.

Methods

The study included 73 medical students across two cohorts (first-year MD3 and second-year MD5). It used a one-group pretest-posttest design with clinical vignette questionnaires. In addition to the integrated lectures, students participated in interactive in-class assignments, like one-line answers and flowcharts, to encourage real-time engagement and provide formative feedback.

Results

The results showed significant improvement in learning outcomes for both groups. The first-year MD3 students' average scores rose from 5.19 to 7.40, while the second-year MD5 students' scores increased from 2.73 to 4.87. Both results were statistically significant (p-value<0.001). In-class activity scores, which averaged 4.45 for MD3 and 3.82 for MD5, confirmed high levels of student engagement and participation.

Conclusions

In conclusion, this integrated-shared teaching model, when combined with in-class assessments, demonstrably improves knowledge acquisition and retention in basic science medical education. By fostering interdisciplinary connections and reducing cognitive load, this method helps cultivate the critical thinking skills essential for future medical professionals.

Keywords: integrated-shared teaching; in-class assessment; cognitive learning theory.

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INTRODUCTION

Medical education is challenged by the vast knowledge students must acquire, leading to overwhelm and poor retention.[1,2] This highlights a need for pedagogical strategies that foster sustained learning, motivation, and deeper understanding.[3] As educators seek to optimize effectiveness, there is a clear shift from passive, traditional lectures toward interactive, student-centered learning.[4] Traditionally, medical education relied on cost-effective didactic lectures.[5] However, there's a clear shift to more engaging, student-centered learning.[6] This transition from passive information delivery to dynamic, interactive environments leads to more impactful learning outcomes. Modern medical curricula emphasize integration, especially vertical integration to make basic science more meaningful by combing it with clinical experiences.[7,8] Grounded in cognitive learning theory, out new teaching model integrates physiology, biochemistry and pathology into organ system sessions. It uses in-class activities to improve knowledge retention and skill application.[9] This study seeks to evaluate the efficacy of this combined integrated-shared teaching and in-class assignment model.

METHODS

This study employed a one-group pretest-posttest evaluation design to assess student learning following an integrated-shared teaching intervention with in-class activities. The study was conducted at Xavier University, School of Medicine, Aruba, during the 2023 spring semester. This study included 73 medical students: 43 from the 1st year (MD3) and 30 from the 2nd year (MD5). All students present in the classroom who expressed willingness to participate were included. The study protocol received approval from the Institutional Review Board (IRB) of Xavier University School of Medicine (XUSOM) (Ref No. XUSOM/IRB/2023/05/002). An integrated-shared teaching session was collaboratively planned by faculty members from the Physiology, Biochemistry, and Pathology departments. Specific learning objectives for each session were discussed and agreed upon by all instructors. Each learning objective was taught by the relevant subject expert (e.g., physiologist, biochemist and pathologist) to ensure specialized instruction. For assessment, identical pre- and post-knowledge tests were administered. Each test comprised nine multiple-choice questions (MCQs) with five options, including three questions from each of the three subjects taught. Students were allotted one minute to answer each question. For MD3 students, the tests focused on the Central Nervous System, specifically basal ganglia. This included questions on basal ganglia input nuclei, neurotransmitters involved in striatum-globus pallidus connections, neural pathways affected in Parkinsonism, and genetic disorders related to mitochondrial proteins and trinucleotide repeats affecting the nervous system. For MD5 students, the tests focused on the Cardiovascular System, specifically myocardial infarction. This included questions on ECG interpretation, cardiac biomarkers, and morphological changes associated with myocardial infarction. Tests were administered via Google Forms, and all student responses were digitally recorded in Google Classroom. The complete questionnaires for both MD3 and MD5 pre- and post-tests are provided as shown in Table 1 and Table 2 respectively.

Additionally, a class worksheet containing five questions was used for in-class activity. Questions were designed to elicit one-line answers or conceptual responses and involved the interpretation of flowcharts. These questions were prepared in advance and directly related to the specific learning objectives presented by the respective subject teachers during the session. Each student received a worksheet at the beginning of the class. Following the instruction of a particular learning objective, students were instructed to answer the corresponding questions on the worksheet within a two-minute timeframe per question. All completed worksheets were collected, and the total number of correct answers for each student was recorded. An average in-class activity score was then calculated for each class (MD3 and MD5). Statistical analysis was performed to evaluate the efficacy of the integrated-shared teaching model. Paired t-tests were used to compare the mean pretest and posttest scores for both MD3 and MD5 student cohorts. This specific test was chosen to assess within-group differences, as it accounts for the dependent nature of the pre- and post-intervention measurements from the same participants. A p-value <0.05 was considered statistically significant, indicating that any observed improvements in scores were unlikely to be due to chance.

In addition to the pretest-posttest score comparisons, descriptive statistics were employed to analyze the in-class activity scores. For each cohort (MD3 and MD5), the average in-class activity score was calculated. These scores provided insights into the level of student engagement and immediate comprehension during the interactive components of the teaching sessions. While not subjected to inferential statistical tests for group comparison, these descriptive measures were crucial for understanding participation and formative learning. All student responses from the Google Forms (for pre- and post-tests) and the collected in-class worksheets were meticulously recorded. The data was then organized and processed to calculate individual and group performance metrics, forming the basis for the paired t-test analyses and the descriptive statistics of the in-class activities.

RESULTS

The study analyzed student performance through pretest and posttest scores using paired t-test analysis, alongside average scores from in-class activities. The number of correct responses for individual questions (pretest vs. posttest) was also analyzed. For MD3 students (n=43), pre-test results indicated that the question "Which of the following disorder is associated with mutation of a nuclear gene that encodes for a mitochondrial protein?" yielded the lowest number of correct responses (n=7, 16.3%). Conversely, the question "Substantia nigra pallor is seen in which of the following condition?" had the highest (n=38, 88.4%). Following the intervention, post-test scores showed improvement across all questions. The question "Which of the following disorder is associated with mutation of a nuclear gene that encodes for a mitochondrial protein?" still recorded the lowest correct responses (n=25, 58.1%), while "The neural pathway that is affected in Parkinsonism is:", "Substantia nigra pallor is seen in which of the following condition?", and "Predominant manifestation of Basal ganglia lesion is:" each achieved the highest number of correct responses (n=39, 90.7% each). These detailed response frequencies and percentages are presented in Table 1.

For MD5 students (n=30), the pre-test revealed that the question "Which of the following occurs in a myocardial infarct at 12-weeks if compared to features of a 9-week-old infarct?" had the fewest correct responses (n=24, 13.3%). In contrast, "Which biomarker persists longer?" and "What predominant feature would you expect to find microscopically in

Table 1. Distribution of correct responses among MD3 students in pre-test and post test assessments. (n=43)

Questions	Correct Responses	
	Pre-test n(%)	Post-test n(%)
1. Which nuclei receives the input from the cortex into the basal ganglia?	26(60.5)	35 (81.4)
2. The neurotransmitter involved in the connections between striatum to the globus pallidus is:	19(44.2)	33(76.7)
3. The neural pathway that is affected in Parkinsonism is:	32(74.4)	39(90.7)
4. Which of the following disorders is associated with mutation of a nuclear gene that encodes for a mitochondrial protein?	7(16.3)	25(58.1)
5. A hemizygous mutation in one of the following genes can be associated with ataxia, as well as premature ovarian failure. Identify the gene:	24(55.8)	35(81.4)
6. Which of the following types of mutation best describes Trinucleotide repeat disorder?	23(53.5)	36(83.7)
7. Which of the following areas of the subcortical nuclei are severely atrophied in Huntington Disease?	22(51.2)	36(83.7)
8. Substantia nigra pallor is seen in which of the following conditions?	38(88.4)	39(90.7)
9. Predominant manifestation of Basal ganglia lesion is	31(72.1)	39(90.7)

a 3-day old Myocardial infarct?" recorded the highest pre-test correct responses (n=19, 63.3% each). Post-test results demonstrated overall improvement. The question "Identify the ECG changes in the patient" (Second instance) had the lowest post-test correct responses (n=6, 20.0%), while "What predominant feature would you expect to find microscopically in a 3-day old Myocardial infarct?" achieved the highest (n=24, 80.0%). Comprehensive data for MD5 students are presented in Table 2.

The in-class activity scores reflected student engagement. The MD3 group achieved an average score of 4.45, suggesting high participation. The MD5 group recorded an average score of 3.82, also indicating active participation.

DISCUSSION

This study evaluated the efficacy of an integrated-shared teaching approach combined with interactive in-class activities in enhancing student learning in basic science medical education. The significant improvements in post-test scores for both MD3 and MD5 cohorts, alongside strong in-class engagement, support that this model fosters deeper understanding and retention, crucial in today's extensive medical curricula.The statistically significant improvements from pre-test to post-test (p-value<0.001 for both cohorts) suggest more than rote memorization; they point to profound cognitive processing consistent with cognitive learning theory (CLT).[10] Our integrated approach likely facilitated this by presenting interconnected concepts across Physiology, Biochemistry, and Pathology in a unified context, promoting coherent knowledge structures and aligning with dual-coding theory by using both verbal and visual forms.[11]

A key strength is the model's ability to manage cognitive load. By intentionally designing integrated sessions, we minimized extraneous cognitive load (redundant information, bridging disciplinary gaps), allowing students to focus on intrinsic and

Table 2. Distribution of correct responses among MD5 students in pre-test and post test assessments. (n=43)

Questions	Correct Responses	
	Pre-test n(%)	Post-test n(%)
1. Identify the ECG changes in the patient.	9(30.0)	14(46.7)
2. Identify the ECG changes in the patient.	6(20.0)	6(20.0)
3. Identify the isoelectric line on the ECG.	17(56.7)	23(76.7)
4. Identify the peak A in the cardiac biomarkers graph.	5(16.7)	20(66.7)
5. Which biomarker peaks earliest?	5(16.7)	19(63.3)
6. Which biomarker persists longer?	19(63.3)	19(63.3)
7. What will be the gross appearance of the heart wall after 3 hours of Myocardial infarction?	5(16.7)	13(43.3)
8. What predominant feature would you expect to find microscopically in a 3-day old Myocardial infarct?	19(63.3)	24(80.0)
9. Which of the following occurs in a myocardial infarct at 12-weeks if compared to features of a 9-week-old infarct?	4(13.3)	17(56.7)

The MD3 students' mean test scores improved significantly from the pretest to the posttest, showing a statistically significant improvement with a p-value<0.001 (Table 3).

Table 3. Comparison of mean pretest and posttest scores for MD3 students. (n=43)

Assessment (Total score = 9)	Mean± SD	Standard Error Mean	p-value
Pretest	5.19 ± 2.107	0.321	
Posttest	7.40 ± 1.530	0.233	<0.001

The MD5 students' mean test scores improved significantly from the pretest to the posttest, showing a statistically significant improvement with a p-value<0.001 (Table 4).

Table 4. Comparison of mean pretest and posttest scores for MD5 students. (n=30)

Assessment (Total score = 9)	Mean ± SD	Standard Error Mean	p-value
Pretest	2.73 ± 1.230	0.225	
Posttest	4.87 ± 2.345	0.428	<0.001

germane load (understanding new material and schema construction).[12] In-class activities with one-line answers and flowchart interpretations offered immediate, low-stakes practice. This active recall and application, akin to spaced repetition and active learning, enhances long-term retention. Prompt feedback during activities further promotes elaboration, strengthening memory traces.[2]

The vertical integration model, linking basic sciences to clinical relevance, aligns with Wijnen-Meijer et al., findings on promoting deeper, meaningful learning.[8] Multidisciplinary content likely increased student motivation and engagement.[13] Faculty collaboration, essential as per Peiman et al., ensured consistent messaging and a unified learning experience.[11] This teamwork also models interprofessional collaboration for students. In-class activity scores (MD3: 4.45; MD5: 3.82) quantify active student participation and immediate comprehension. These activities, integral learning tools, fostered real-time engagement and formative feedback, consistent with active learning principles.[6,12] Our specific use of responses required active processing, synthesis, and immediate demonstration of understanding.[14]

Success of in-class activities echoes findings from technology-enhanced interactive strategies. Cox in 2019 showed audience response systems boost discussion[15] and Wang et al., demonstrated WeChat's role in active learning and feedback.[16] These studies, like ours, emphasize deliberately designed interactive elements in converting passive learners to active participants, maximizing learning. Immediate feedback is vital for enhancing self-regulation and meta-cognition. The slight difference in in-class activity scores between MD3 and MD5 (MD3 higher) could stem from differences in topic complexity (CNS vs. CVS), student maturity, or prior exposure. However, the overall positive impact on learning was consistent. This implicitly supports the transition to student-centered methods, improving academic outcomes and cultivating critical thinking essential for future medical professionals.

The study's integrated-shared teaching model directly reflects recent Cognitive Load Theory applications in medical education. By unifying physiology, biochemistry, and pathology, it minimizes extraneous cognitive load from fragmented curricula, a key focus in current CLT research.[17] The interactive in-class activities, which showed high engagement, actively promote germane cognitive load, aligning with findings from Sewell et al., on optimizing learning in complex medical contexts.[18] This strategic design helps students process information more effectively, leading to the observed significant improvements.

Limitations

The time spent by the faculty in the pre-class discussion before every session adds to the additional work, which might be a barrier to its widespread implementation without proper administrative support. More faculty are involved in the session when compared to only one teacher in the non-integrated sessions, requiring greater coordination and resource allocation. The number of questions for the in-class activity was relatively small, and there is a need for more questions to further enhance the assessment of learners' performance in the classroom. Future studies could explore the long-term retention of knowledge and compare this integrated approach with other active learning strategies in a randomized controlled trial setting.

CONCLUSIONS

This study demonstrates a significant and positive impact of the integrated-shared teaching model combined with in-class activities on student learning outcomes in basic science medical education. The observed improvements in pretest to posttest scores across both MD3 and MD5 student cohorts strongly indicate that this approach effectively enhances knowledge acquisition and retention. These findings provide valuable insights into the benefits of interdisciplinary teaching and active engagement for improved educational effectiveness.

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