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Impact of clinical case studies and experimental practices on the academic performance of second-semester students in Medical Biochemistry.

Impacto de la aplicación de casos clínicos y prácticas experimentales en el rendimiento académico de estudiantes de segundo semestre en Bioquímica Médica.

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Summary: Introduction: Medical Biochemistry is a fundamental subject in the training of medical students, although it is often perceived as abstract and difficult to understand. This situation impacts on poor academic performance and the poor connection with clinical practice. **Objective**: To evaluate the impact of a teaching strategy based on clinical cases and experimental practices on the academic performance of second-semester students in the subject of Medical Biochemistry. **Methods**: A quasi-experimental study with 137 students distributed in four parallel classes. A pedagogical intervention was applied integrating clinical case analysis with laboratory practices. Learning was assessed through theoretical pretest, integrative clinical posttest and practical grades. Student t-test, ANOVA and Pearson correlation were used. **Results**: Academic performance improved significantly after the intervention (M pretest = 4.57; M posttest = 8.43; $p < 0.001$), with a large effect size (d = 1.13). The ANOVA analysis revealed significant differences between parallels ($p < 0.001$). A moderate positive correlation was observed between the posttest and the theoretical-practical overall GPA (r = 0.640; $p < 0.001$). **Conclusions**: The implementation of clinical cases and experimental practices had a positive impact on academic performance, promoting meaningful learning and the integration of biochemical theory and clinical reasoning. Their systematic application in the basic medical sciences curriculum is recommended.

Keywords: Clinical cases, active learning, laboratory practice, academic performance, medical teaching, Biochemistry.

Resumen: Introducción: La Bioquímica Médica es una asignatura fundamental en la formación de los estudiantes de medicina, aunque frecuentemente se percibe como abstracta y de difícil comprensión. Esta situación repercute en el bajo rendimiento académico y la escasa conexión con la práctica clínica. **Objetivo**: Evaluar el impacto de una estrategia didáctica basada en casos clínicos y prácticas experimentales sobre el rendimiento académico de estudiantes de segundo semestre en la asignatura de Bioquímica Médica. **Métodos**: Estudio cuasi-experimental con 137 estudiantes distribuidos en cuatro paralelos. Se aplicó una intervención pedagógica integrando análisis de casos clínicos con prácticas de laboratorio. Se evaluó el aprendizaje mediante pretest teórico, postest clínico integrador y calificaciones prácticas. Se emplearon pruebas t de Student, ANOVA y correlación de Pearson. **Resultados**: El rendimiento académico mejoró significativamente tras la intervención (M pretest = 4,57; M postest = 8,43; $p < 0,001$), con un tamaño del efecto grande (d = 1,13). El análisis ANOVA reveló diferencias significativas entre paralelos ($p < 0,001$). Se observó una correlación positiva moderada entre el postest y el promedio general teórico-práctico (r = 0,640; $p < 0,001$). **Conclusiones**: La implementación de casos clínicos y prácticas experimentales tuvo un impacto positivo en el rendimiento académico, favoreciendo el aprendizaje significativo y la integración entre teoría bioquímica y razonamiento clínico. Se recomienda su aplicación sistemática en el currículo de ciencias básicas médicas.

Palabras clave: Casos clínicos, aprendizaje activo, práctica de laboratorio, rendimiento académico, enseñanza médica, Bioquímica.

1. Introduction

Many young people enter the Medical School at San Gregorio de Portoviejo University with the desire to build a solid professional future committed to the health of the population. However, throughout the training process, they face various academic difficulties that affect their performance and permanence (1). As the semesters pass, significant differences in student performance are evident, reflected mainly in the grades obtained (2). This reality also impacts the basic subjects taught at the first levels, such as Medical Biochemistry, whose mastery is essential to understand the pathophysiological processes and establish the bases of clinical reasoning (3).

Medical Biochemistry, by articulating molecular knowledge with biological and clinical mechanisms, represents a fundamental axis in comprehensive medical training (4). However, it is frequently perceived by students as an abstract and highly difficult subject, which can diminish their motivation and understanding (5). In this context, there is a need to transform teaching strategies, adopting active, participatory and contextualized approaches that promote meaningful and lasting learning (6).

Among these strategies, the integration of simulated clinical cases and guided experimental practices has proven to be an effective tool to link theoretical content with clinical practice (7), strengthen critical thinking, and improve academic performance (8). These methodologies allow students to apply biochemical concepts in solving real-life problems, analyze laboratory results, interpret biochemical markers, and correlate them with specific pathophysiological situations (5, 9).

Within this framework, this study aims to evaluate the impact of clinical case studies and experimental practices on the academic performance of second-semester students in Medical Biochemistry. It seeks to demonstrate how these teaching strategies contribute to improving understanding, motivation, and academic performance in a key subject for early medical education.

2. Methods

Study design

A quasi-experimental study (10) was conducted with a quantitative approach, using a pretest-posttest design without a control group. The pedagogical intervention consisted of the application of contextualized clinical cases and integrated experimental practices, as teaching strategies in the subject of Medical Biochemistry.

Participants

The study population consisted of 137 second-semester students of the Medicine program at the Universidad San Gregorio de Portoviejo, distributed in four parallels (A, B, C and D), during the academic period October 2024-March 2025. All enrolled students who attended the practical activities and took both evaluations (pretest and posttest) were included.

Educational intervention

The strategy was developed in four structured sessions, which allowed the student to move from initial theoretical understanding to practical and clinical application, consolidating significant learning .

- Session 1: Application of the diagnostic pretest and introductory explanation of key biochemical concepts.
- Session 2: Laboratory practice (glucose determination) accompanied by an initial clinical case; group discussion and immediate feedback.
- Session 3: Continuation of experimental practices (cholesterol, urine, uric acid) combined with three additional clinical cases; analysis of results in teams and correlation with pathophysiological situations.

- Session 4: Final integration of learning, resolution of clinical problems and application of the integrative post-test.

The methodological strategy included four laboratory practices accompanied by a representative clinical case, followed by technical execution and analysis of results, encouraging team discussion and pathophysiological reasoning:

- Determination of blood glucose using the colorimetric enzymatic method (glucose oxidase-peroxidase).
- Quantification of HDL and LDL cholesterol using the colorimetric method with enzymatic reagent.
- Physical-chemical and microscopic examination of urine using test strips and sediment analysis.
- Determination of serum uric acid using the uricase-peroxidase enzymatic technique.

Data collection instruments

Two evaluation instruments were applied:

- Diagnostic pretest: 20 multiple-choice items focused on theoretical content and biochemical foundations.
- Final posttest: 25 integrative items with a clinical focus and problem-solving, developed from the clinical cases used.

The tests (pretest and posttest) were designed using expert judgment and subjected to pilot analysis where item quality indicators were evaluated. Item analysis was applied and an internal reliability coefficient was estimated (Cronbach alpha $\geq$ 0.80). Comparative studies validated similar MCQ-type razz-tests in basic areas such as molecular biology and biochemistry, reporting reliable validity and reliability indices (11). In addition, a practical evaluation rubric was used to grade laboratory performance developed by the researcher, considering criteria such as: application of theory, proper use of equipment, development of the procedure and analysis of results. The score was out of 20 points.

Evaluation and feedback criteria.

The final grade was obtained by weighting the following components: pretest (20%), laboratory practice performance (30%), clinical case analysis (20%), and integrative posttest (30%). After each practice, group feedback was provided to discuss common errors and reinforce key concepts. In the posttest, a parallel results report was submitted, accompanied by a plenary discussion of correct and incorrect answers, ensuring a training process that went beyond simple grading.

Statistical analysis

For data analysis, IBM SPSS Statistics version 27 was used, in which a structured database with ten variables was constructed. These included: the student's identification number (ID), the academic or parallel group to which they belonged (Group), the grade obtained in the diagnostic pretest administered before the intervention (Pretest), and the grade in the final posttest administered after the intervention (Posttest). The difference between both evaluations (Difference) was also calculated as a measure of academic improvement. In addition, the grades obtained by each student in the four experimental practices were recorded: glucose determination (GLUCOSE P), HDL and LDL cholesterol determination (CHOLESTEROL), chemical and microscopic urine examination (URINE EXAMINATION), and uric acid determination (URIC ACID P). From these, the average performance in the experimental practices (AVERAGE) was obtained. All quantitative variables were treated as scales, except for the Group variable, which was coded as nominal. Statistical analysis included descriptive statistics (mean and standard deviation) and inferential statistics. Student's t-test was used for related samples to compare pre- and post-test scores, verifying whether significant differences existed after the educational intervention. A one-way ANOVA was also used to determine differences in academic performance between the different

parallel subjects, and a Pearson correlation was calculated between the average of the practical exercises and the post-test result to explore relationships between practical performance and final theoretical performance. In all cases, a level of statistical significance of $p < 0.05$ was considered.

The study was conducted in compliance with the ethical principles of educational research (12). Student participation was voluntary and anonymous, and informed consent was obtained before the assessment instruments were administered. Furthermore, data were treated with strict confidentiality, ensuring their exclusive use for academic and research purposes.

3. Results

A total of 137 students were included, distributed across four academic periods. Academic performance was assessed before and after the intervention using a theoretical pretest and an integrative clinical posttest. The overall mean score for the pretest was 4.57 points (SD = 0.99), while the mean score for the posttest was 8.43 points (SD = 0.85), demonstrating a significant increase following the implementation of the pedagogical strategy. The t-test for related samples showed a statistically significant difference between the two periods ($t = -39.97$; $df = 136$; $p < 0.001$), with a mean improvement of 3.86 points. Furthermore, a moderate positive correlation was observed between the two tests ($r = 0.255$; $p = 0.003$), suggesting a consistent trend between the initial and final performance. The effect size, measured by Cohen's d (1.13), was classified as very large, indicating that the intervention had a substantial pedagogical impact on student learning.

Improved academic performance after the intervention.

The analysis of the results by parallel group shows a general improvement in students' academic performance after the implementation of clinical cases and experimental practices. A total of 137 students were included, distributed across four parallel groups (A, B, C, and D), with no cases excluded from the analysis. The overall mean score in the pretest was 4.57 points (SD = 0.99), while the mean score in the posttest was 8.43 points (SD = 0.85), with an overall increase of 3.86 points (Table 1). This positive trend was consistent across all parallel groups: group C showed the greatest improvement ($\Delta = 4.00$), followed by group D ($\Delta = 3.59$), group A ($\Delta = 3.35$), and group B ($\Delta = 1.17$). Furthermore, the mean score for experimental practices also showed a favorable distribution, with means close to 19 points across all groups, suggesting positive participation and performance during the practical sessions. These results support the effectiveness of the implemented teaching strategy, not only in the theoretical dimension assessed in the written tests, but also in the practical dimension, focused on laboratory skills and clinical-situational analysis.

An analysis of variance (ANOVA) was also performed to compare the post-test results between the four academic parallels. The differences were statistically significant ($F = 15.338$; $df = 3,133$; $p < 0.001$), indicating that the impact of the pedagogical intervention varied between groups. Group C obtained the highest GPA (M = 8.80; SD = 0.73), followed by Group D (M = 8.38; SD = 0.82), Group B (M = 8.68; SD = 0.70), and Group A (M = 7.66; SD = 0.69), suggesting that participation and classroom dynamics may have influenced differential performance.

Table 1. Comparison of pre-test and post-test means, average of practices and total difference by academic parallel.

Cluster		Pretest	Posttest	Average Practices	Difference
A	Average	4,313	7,669	19,350	3,356
	N	30	30	30	30
	Standard Deviation	0.8993	0.6939	0.3791	0.8213
B	Average	4,305	8,683	19,224	4,378
	N	34	34	34	34
	Standard Deviation	0.9084	0.7069	0.27486	1.17555
C	Average	4,804	8,808	19,190	4,004
	N	40	40	40	40

	Standard Deviation	0.9412	0.7334	0.3647	1,1172
D	Average	4,793	8,386	19,083	3,592
	N	33	33	33	33
	Standard Deviation	1,1184	0.8252	0.4106	1,1130
Total	Average	4,570	8,426	19,208	3,856
	N	137	137	137	137
	Standard Deviation	0.9906	0.8512	0.3676	1,1293

Correlation between theoretical performance and practical performance.

To determine the relationship between theoretical academic performance (posttest) and practical performance in clinical activities, a Pearson correlation was performed between both variables. The analysis revealed a moderately positive correlation ($r = 0.640$), which was statistically significant ($p < 0.001$).

This result indicates a significant association between students' theoretical and practical performance. In other words, the higher the posttest score, the higher the overall grade point average for both practical and theoretical activities. This relationship suggests that students who better consolidated theoretical content were able to transfer that knowledge to practical execution, thus strengthening integrated clinical learning.

4. Discussion

The findings of this study reaffirm the importance of implementing active methodologies in teaching basic biomedical sciences, particularly in subjects perceived as complex, such as Medical Biochemistry. The use of contextualized clinical cases and experimental practices allowed for greater student appropriation of the content, reflected in a significant increase in posttest scores across all parallels.

The observed improvement in theoretical performance and the positive relationship with practical performance corroborate previous studies that highlight the effectiveness of teaching strategies that promote theory-practice integration and meaningful learning (13). Furthermore, the effect size calculated with Cohen's d supports the robustness of the pedagogical impact, placing this intervention among the most effective in the context of teaching Medical Biochemistry.

The intergroup differences observed in the ANOVA also invite reflection on the role of the classroom context, teacher-student interaction, and collaborative environment as factors modulating the success of the intervention. This aspect may suggest that not only the teaching resource, but also the pedagogical environment and teacher mediation significantly influence learning outcomes.

In this sense, the heterogeneity between parallels could be explained not only by the characteristics of the students, but also by the role of the teacher-student relationship and group dynamics. These factors can act as significant modulators of the effectiveness of the pedagogical intervention, reinforcing the idea that teacher mediation constitutes an added value in generating meaningful learning.

The positive and significant correlation between the posttest and the overall grade point average demonstrates an effective transfer of knowledge, facilitating the development of integrated competencies. However, the low or nonexistent correlation between the practical component and theoretical performance in some parallels raises the need to design differentiated strategies to strengthen both cognitive and procedural skills, avoiding learning fragmentation.

Additionally, it is highlighted that this experience strengthened the student's autonomy by promoting the resolution of real clinical problems from a biochemical perspective. This approach,

aligned with the principles of meaningful learning and problem-based learning, fosters a critical, reflective, and collaborative attitude, key to contemporary medical education (4).

From an institutional perspective, the results suggest the advisability of systematizing these strategies in basic science programs, promoting a curricular redesign that guarantees vertical articulation between the basic and clinical aspects, as well as teacher training in active methodologies. The application of this strategy could be replicated and adapted to other subjects in the basic cycle, fostering an integrative and student-centered educational model (14).

The study's limitations include the lack of a control group and its implementation during a single academic period. However, the statistical robustness, internal consistency, and magnitude of the observed change provide valuable evidence of the effectiveness of the implemented methodologies. A significant limitation was the lack of a control group that would allow the results to be compared with traditional methodologies. For future studies, it would be advisable to include previous cohorts or parallel groups under comparable conditions to strengthen the external validity of the findings. Future studies could expand the sample, incorporate experimental designs with a control group, and evaluate the sustainability of the impact in the medium and long term. It would also be relevant to investigate the role of variables such as motivation, student perception, clinical thinking, and the development of transversal skills such as communication and teamwork, which would enrich the analysis of the educational impact of these strategies.

5. Conclusions

- The incorporation of clinical cases and experimental practices in Medical Biochemistry significantly improved students' academic performance. The improvement was consistent across all groups, although with intergroup differences that highlight the importance of the classroom context and the teacher-student relationship as critical pedagogical variables.
- The positive correlation between theoretical and practical performance suggests an effective transfer of knowledge to applied contexts, reinforcing the relevance of an integrated teaching approach. Furthermore, the significant difference between pre- and post-intervention scores, supported by a high effect size, confirms the formative impact of the methodology applied.
- It is recommended that health sciences programs adopt similar approaches as part of an institutional pedagogical policy that promotes active, contextualized, and student-centered learning. Longitudinal monitoring is also necessary to assess the sustainability of the impact at higher levels of training and its impact on actual clinical practice.

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6. References.

1. Espinales Párraga KA, CCJE, GVWG. Medical students and their academic performance in Ecuadorian universities. *Rev Soc Frontera.* **2024**, 4, 148. https://doi.org/10.59814/resofro.2024.4(1)148
2. Guaresti G. Curricular integration and innovation: feedback from students in the first cohort of the medical program at the National University of Río Negro, Argentina. *RECS*. **2025**, 1, 1–10. https://doi.org/10.70165/cglobal.v9i1.369
3. Bernabé Lillo MdlL, SSPR, EME, APIM, MAA. Learning strategies in Ecuadorian university students: a case study in the province of Esmeraldas. *Rev Andina Educ*. **2022**, 5, 529. https://doi.org/10.32719/26312816.2022.5.2.9

4. Batista Garcet Y, MMLJ, VBL. Virtual teaching-learning environments for knowledge building in medical biochemistry in the USGP medical school. *Global Knowledge*. **2024**, 9, 307–20. https://doi.org/10.70165/cglobal.v9i1.369
5. Alamoudi AA, AlSLA, GH, TA. Team-based learning versus traditional didactic lectures in teaching clinical biochemistry at King Abdulaziz University: learning outcomes and student satisfaction. *Biochem Mol Biol Educ.* **2021**, 49, 546–59. https://doi.org/10.1002/bmb.21501
6. Dolmans DHJM, LSMM, MH, GD. Deep and surface learning in problem-based learning: a review of the literature. *Adv Health Sci Educ*. **2016**, 21, 1087–112. https://doi.org/10.1007/s10459-015-9645-6
7. Byrne CE. Teaching proposal based on the use of a high-performance liquid chromatography (HPLC) simulator as a complement to the practical activities of the Instrumental Analytical Chemistry course. *Repositorio Institucional de la UNLP*. **2025**, 1, 1–15. http://sedici.unlp.edu.ar/handle/10915/179154
8. Based on EA, OSL, HY. Developing critical thinking in problem-based learning environments among higher education students. *Rev Mex Invest Educ*. **2012**, 17, 759–78. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1405-66662012000300004
9. Schönborn KJ, ATR. Bridging the educational research-teaching practice gap. *Biochem Mol Biol Educ.* **2010**, 38, 347–54. https://doi.org/10.1002/bmb.20436
10. Manterola C, OT. Experimental studies. Part 2: quasi-experimental studies. *Int J Morphol.* **2015**, 33, 382–7. http://dx.doi.org/10.4067/S0717-95022015000100060
11. Avianna J, NMS. Validity and reliability of a multiple-choice biology exam: A Rasch analysis perspective. *Rev Int Educ Mod*. **2025**, 1, 1–10. https://gaexcellence.com/index.php/ijmoe/article/view/313
12. Below, Francisco J. de. The Declaration of Helsinki VI: A necessary revision, but is it sufficient? *Rev. Esp. Salud Publica.* **2001**, 75 (5), 407-420. https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1135-57272001000500002
13. Burbano Palacios EF. Teaching and its practices as a catalyst for meaningful learning. RIDE *Rev Iberoam Invest Desarro Educ*. **2024**, 15, 3. https://doi.org/10.23913/ride.v15i29.2123
14. Osses Bustingorry SE, CDLE, GNJL. The effect of a pedagogical strategy on the metacognitive development of Chilean adolescents. *Estud Pedagóg (Valdivia*). **2018**, 44, 69–88. http://dx.doi.org/10.4067/S0718-07052018000100069