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Research Article

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Integrated Teaching and Perspectives in Basic Subjects - Physiology/Biochemistry

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Abstract

To improve the quality of teaching the basic subject of biochemistry and increase students' motivation to study it, we introduced an integrated physiology/biochemistry course in the MD curriculum. The course was divided into topic-based blocks covering the basic sciences. The implementation of the integrated courses using both teaching methods (lectures and seminars) and modern, student-centred approaches (Problem-Based Learning) demonstrated that students were receptive to the learning activities and were no less interested in biochemistry than in physiology ($p<0.05$). The students' interest in neuroscience was attributed to the integration of topics and their strong correlation with diseases. In accordance with the learning objectives, these findings may serve as a useful guideline for medical educators seeking to introduce scientific concepts and prepare medical students for the practice of evidence-based, science-oriented medicine.

Keywords: Medical Curriculum, Basic Sciences, Integration; Clinical Correlation, Critical Thinking, Reasoning, Active Learning

1. Introduction

Medical education today spans three sectors: undergraduate, postgraduate, and the continuing professional development of established clinicians. Medical education is busy, where host pedagogical practices, educational philosophies, and conceptual frameworks collide. The ultimate aim of medical education is to supply society with knowledgeable, skilled, and up-to-date personnel of healthcare professionals who put patient care above self-interest and maintain and develop their expertise throughout a lifelong career. Patient safety issues permeate undergraduate medicine. Protecting patients within a teaching and learning environment while producing competent doctors who will maintain their knowledge, attitudes, and skills is a challenge for those who design undergraduate curricula [1].

Sound knowledge and understanding of basic sciences are prerequisites for completing medical education successfully. Therefore, improving the quality of teaching and ensuring its application is essential [2].

Fundamental knowledge of basic sciences is a primary determinant of diagnostic success because numerous modern devices and methods used for diagnosis and treatment are based on that [3,4]. Nevertheless, there is a significant variance in students' basic science knowledge at the beginning of medical education.

Insufficient knowledge of basic sciences can lead to a lack of understanding of fundamental biochemical, physiological, and pathophysiological principles, causing students' dropout [5]. Due to this challenging task, medical schools developed various methods to prepare their students for the medical curriculum. For instance, pre-medical courses are offered in many countries [6-8].

Within the framework of the guidelines, particular emphasis was placed on the vertical integration of the basic sciences across all phases of the curriculum (preclinical, clinical, and clerkship), using evidence-based teaching strategies and deliberate curricular spiral integration. Such vertical integration is known to influence not only knowledge acquisition but also students' motivation, professional identity formation, and the transition to independent

medical practice [9,10].

Regarding specific teaching topics, the recommendations underscore that basic sciences should be taught within a clinical context. The instructional topics chosen for the preclinical phase should focus on need-to-know topics aimed at developing critical thinking skills, understanding that more advanced medical science topics will be revisited post-clerkship [11].

The teaching styles of the basic sciences and the medical sciences differ. The modern integrated teaching uses problem-based learning (PBL). The research shows no distinction between students' academic performance based on the use of these educational philosophies [12].

The result of the initiative includes an increase in the number of courses offered in the medical curriculum, the growth of medical education units within medical schools and greater interest in medical education generally.

Basic medical education in the UK has undergone substantial reform over the past 15 years. The central aims of these reforms included reducing the volume of factual content in the curriculum, placing greater emphasis on skills acquisition, eliminating the traditional preclinical/clinical divide, and expanding the role of community-based teaching and learning. Although several key developments are outlined, reform continues in other areas. The initiative has increased the number of courses offered within the medical curriculum, expanded medical education units within medical schools, and grown interest in medical education more broadly.

Central aims of the reform included a reduction of factual content in the curriculum, greater prominence of skills acquisition, eradication of the pre-clinical/clinical divide and a higher profile for community-based teaching and learning. Some of the major developments are outlined, although change continues in other areas. Consequences of the initiative include greater choice in the courses now offered to applicants to medical school, the growth of medical education units within medical schools and greater interest in medical education generally [13].

The Charité Medical University of Berlin (Charité Universitätsmedizin Berlin) offers both a traditional medical curriculum (TMC) and a Problem-Based Learning (PBL) reformed medical curriculum (RMC). Students in both curricula take the Progress Test in Medicine (PTM), which assesses competencies in the basic and clinical medical sciences throughout their medical education, from the first to the final semester [12].

In addition to retaining previously acquired knowledge, undergraduate students must incorporate recent advances in clinical practice and integrate these with their existing understanding by interpreting and applying concepts from the basic medical sciences. Frequently, areas well known to the basic scientist but rarely explored by the clinical specialist become crucial to the success of new clinical procedures. For example, the use of surgical robots and interventional procedures with minimal access surgery, as in radiofrequency ablation of cardiac arrhythmias, necessitates a solid understanding not only of detailed anatomical relationships within the heart but also of the heart's electrophysiology. A detail once considered extraneous has renewed significance and is often critical to the success of a clinical procedure. Therefore, integration of basic sciences into the later years of the medical curriculum and, more so, postgraduate specialization is growing in popularity. A return to the basic sciences during the later years of the medical curriculum, when students' clinical reasoning and analytical skills are more refined, enables learners to better integrate basic science concepts into their clinical experience [14].

Educators must now prepare scientifically competent graduates who function effectively as professionals amid ongoing healthcare reforms. Understanding the scientific foundation of medical practice and applying this knowledge to inform decisions about patient care are essential competencies of a physician [15].

The overarching objective of basic medical science education is to provide fundamental scientific theories and concepts and their application into clinical practice. Traditionally, the basic medical sciences have comprised disciplines such as anatomy, histology, physiology, biochemistry and pathology. Contemporary curricula have expanded to include genetics, cell and molecular biology, epidemiology, nutrition and energy metabolism, healthcare delivery science, and bioinformatics. Medical education progressively shifted from the traditional Flexnerian model toward an integrated curriculum, in which basic science subjects are either paired with related clinical disciplines (e.g. anatomy/radiology, immunology/pathology, neuroscience/psychiatry) or integrated into organ-system-based blocks. These blocks are typically coordinated by faculty from both basic science and clinical departments, facilitating the integration of foundational scientific knowledge with early clinical exposure and enabling students to apply basic science concepts in patient care settings [16].

1.1. Physiology and Biochemistry in the MD curriculum of SEU

It is widely recognized that biochemistry is one of the most difficult and least favored subjects among medical students. Many medical students perceive biochemistry as having limited relevance to their future clinical practice, while practicing physicians similarly perceive its relevance to their daily clinical practice as limited [17]. In a previous study, the majority of students perceived anatomy and physiology as the most relevant subjects to the medical curriculum, whereas medical biochemistry was considered the least relevant ($P < 0.05$) [18]. These findings highlight the need to refine and improve the methods used to teach biochemistry.

In Georgia, medical students are taught biochemistry from the first semester, while many students admitted to medical schools have already received undergraduate-level instruction in biochemistry [17]. Applicants for admission are selected based on the results of the Unified National Examinations and other admission criteria.

These prerequisites should provide an adequate foundation for undertaking a biochemistry course from the first semester of medical education. However, findings from internal university surveys conducted among students at the end of each semester indicate that biochemistry has consistently been perceived as the least favored subject among medical students. Why do medical students consider biochemistry unnecessary to their education? What can educators do to convince them of the importance of learning biochemistry as part of their medical education? These questions were also raised by Afshar and Han, who addressed them as follows:

Factors negatively affecting medical students' interest in biochemistry:

i. Medical biochemistry often repeats the materials of undergraduate biochemistry
ii. Medical biochemistry is presented mostly outside the context of medical relevance
iii. There is a large portion of the material that seems irrelevant to board examinations
iv. Medical biochemistry requires too much rote memorization that does not last long [17].

Based on the above, an integrated biochemistry and physiology course was developed within the MD curriculum at Georgian National University. The course integrates the teaching and learning of physiology and biochemistry across different organ-system-based blocks. The topics covered in each block are as follows:

- **Block 1: Basic Concepts of General Neurophysiology —** peripheral nervous system, spinal cord, and muscles (Body Function I).
- **Block 2: Central Nervous System and Special Senses —** neuroscience.
- **Block 3: Blood, Cardiovascular, and Respiratory Systems —** Body Function II.
- **Block 4: Gastrointestinal System, Nutrition, Endocrine and Reproductive Systems, Kidneys, and Electrolytes —** Body Function III.

The Neuroscience module represented a unique form of interdisciplinary integration, as no comparable course was identified in the curricula of other universities in Georgia at the undergraduate (bachelor's) level, particularly during the early years of medical education.

We also chose physiology/biochemistry integration because we believe it is beneficial for both disciplines - biochemistry studies the molecular basis of physiological processes and the biochemical basis of clinical correlations. All learning goals and objectives have been researched and reviewed by experts. Educational resources and logistical materials were well prepared. The integrated course, which represented an example of horizontal integration, also contributed to the vertical integration of the curriculum. The examinations are likewise integrated across all modules and include numerous questions based on brief clinical case scenarios, requiring students to integrate and apply knowledge from different disciplines.

The goals of conducting integrated education were outlined as follows:

- To provide the student with integrated knowledge about the structure of organs, body functions and their regulation, the mechanisms underlying physiological and biochemical processes, and their relevance to related diseases.
- To develop students' skills in deep learning and critical thinking.

Integrated training was implemented through temporal coordination of physiology and biochemistry, with teaching topics closely coordinated with relevant clinical contexts.

Integrated topics were selected from all curricular blocks; however, the present analysis focuses on Block 2, Neuroscience. The content was organized around the central nervous system and sensory systems. The module included lectures, problem-based learning (PBL), and laboratory sessions. During these sessions, students were required to present and discuss assigned topics in small groups under the guidance of a facilitator. The schedule was designed so that interrelated topics from different disciplines were taught during the same week. Topics that could not be fully integrated were reorganized to maintain continuity and completeness of the curriculum through lectures, problem-based learning, and laboratory sessions [19,20].

2. Methods

The study was conducted on the One Step Educational Program medicine students from Georgian National University SEU.

The interviewees included both male and female students, with no significant difference in gender distribution, and were aged 20–21 years. Students were selected randomly. Each survey group comprised 30–34 students, representing approximately 50% of the study population.

The survey was conducted online using the Reg.seu.edu.ge platform at SEU during the study period from 2021 to 2024. Survey responses were anonymous, and individual feedback was provided to participants.

The survey was conducted using a questionnaire developed and pilot-tested by the research team. The questionnaire was designed to assess students' level of satisfaction with the outcomes of integrated teaching of the basic medical sciences [21].

2.1. Data Analysis

Data were analyzed statistically using the t-test and chi-square test in Microsoft Excel 2016. Statistical significance was set at $p < 0.05$.

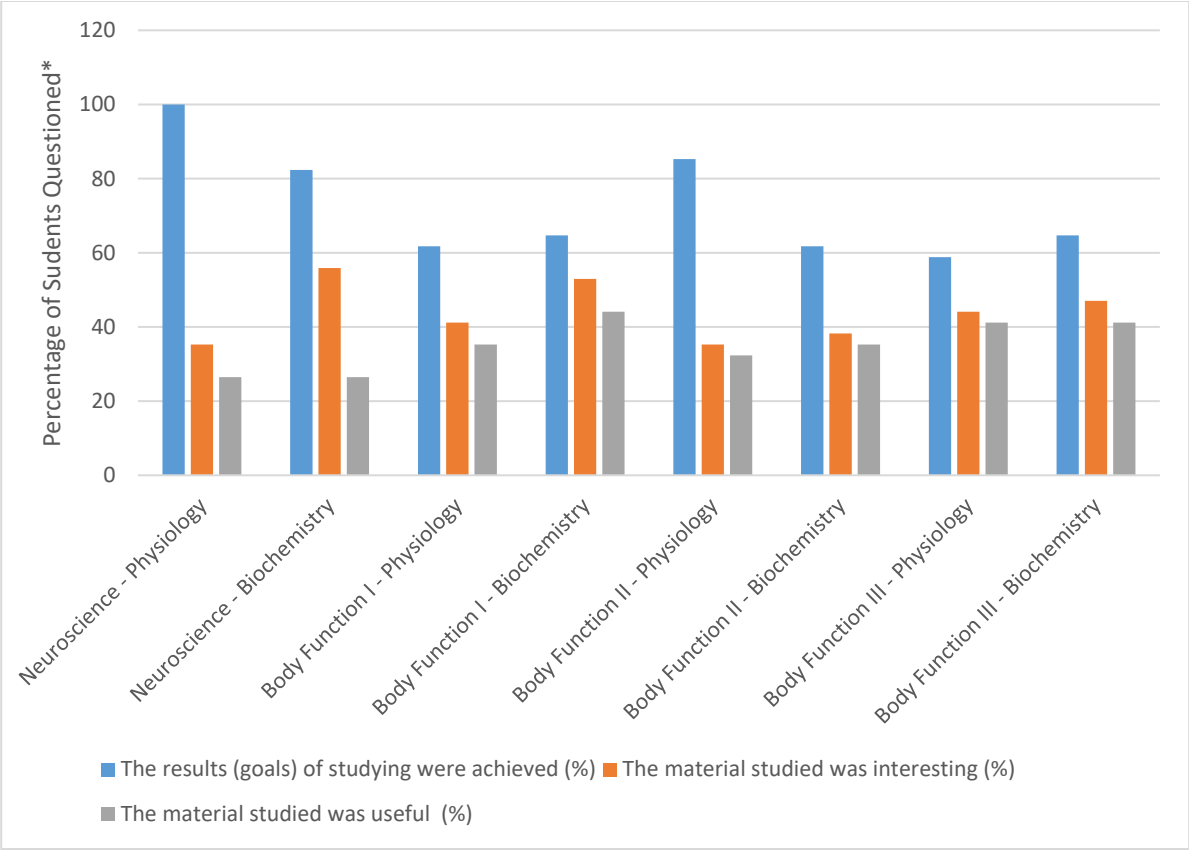
2.2. Ethical considerations

The Ethics Committee of Georgian National University SEU approved the study. The research team adhered to ethical principles throughout all stages of the study. The participants were informed about the study in advance, and participation was voluntary, with all responses collected anonymously.

3. Discussion

The survey of students showed that they were satisfied with the results achieved in all integrated subjects. A particularly high rate was observed in neuroscience - more than 50% in all cases (Figure 1), which was probably because the studied material was entirely based on recent research and review papers. In this case, students found the material interesting; however, they rated the usefulness of the subject relatively low. As shown in the table, students did not rate the "usefulness" of the subject highly across all areas. This may be explained by the vertical integration of the curriculum. At the time of the survey, students had not yet completed clinical courses that built on their foundational knowledge of neuroscience. For the other integrated subjects, students had already studied some of the corresponding clinical subjects. Among subjects with relatively high "usefulness" ratings, students were already studying the relevant clinical courses at the time of the survey, and the integrated subjects examined in this study served as prerequisites for those courses.

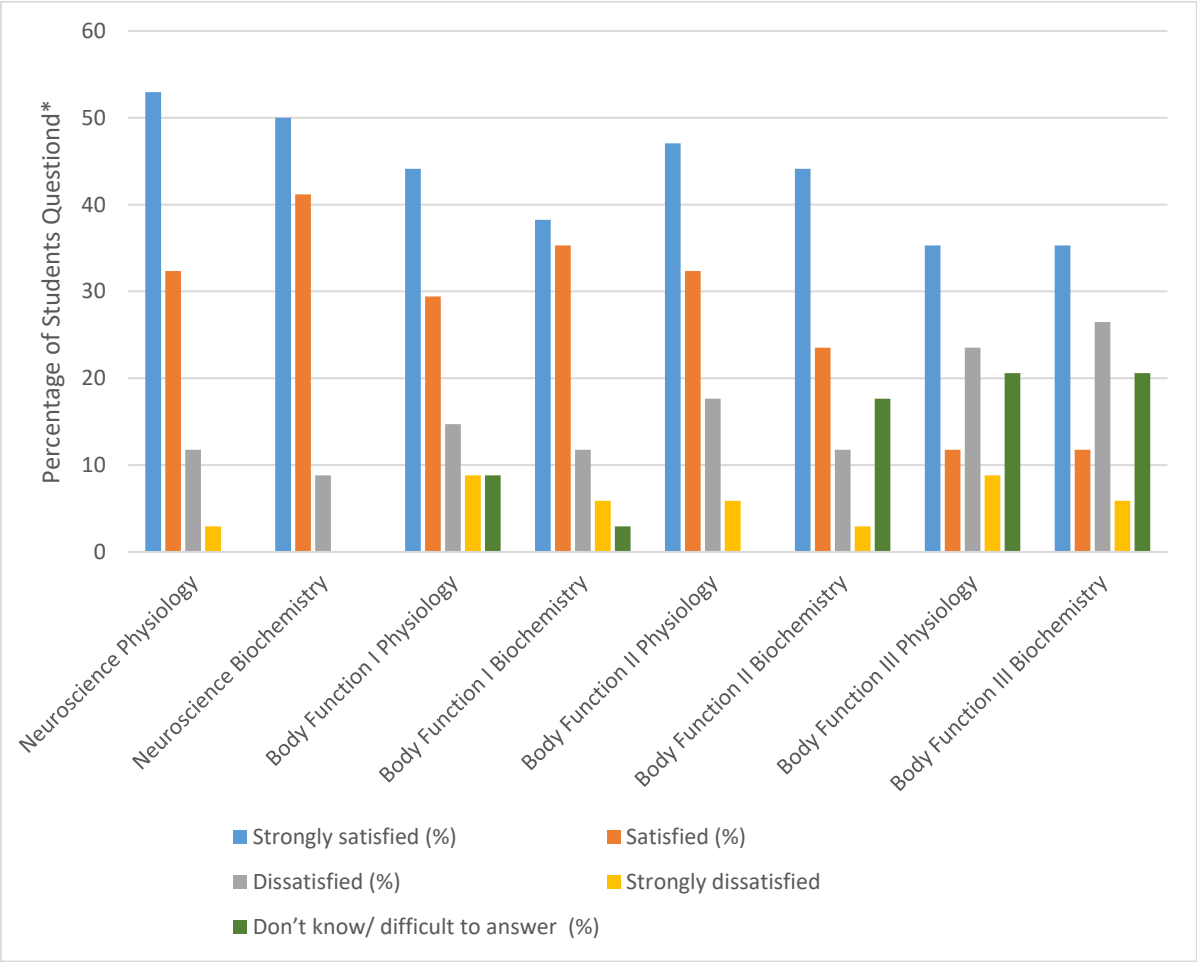
It is noteworthy that students' satisfaction with the material studied and their ratings of the usefulness of these subjects were consistently lower than their ratings of the achievement of the learning outcomes ($p < 0.05$) (Figure 1). Nevertheless, students found the material manageable and did not perceive biochemistry as an undesirable subject.



*The number of students questioned - N=34

Figure 1: The Level of Satisfaction with the Results of Teaching and the Assessment Methods in Basic Subject Blocks (Georgian National University SEU)*

It is worth noting that none of the interviewed students expressed dissatisfaction with neuroscience (Figure 2), nor was the question - I don't know / it's difficult to answer - evaluated positively.



*The number of students questioned - N=34

Figure 2: The Level of Satisfaction with the Basic Subject Blocks (Georgian National University SEU)*

A smaller percentage of students in other integrated courses in the curriculum expressed satisfaction with the subjects. In those cases, the number of dissatisfied students was higher than in neuroscience ($p<0.05$). Also, to the question - I don't know / it is difficult for me to answer - more students gave the negative answer. This may be due to a) the difficulty of the studied material, b) the interests of the students, and c) the received evaluations. It should be noted that the assessment system and teaching methods (interactive lectures, group work, laboratory training, PBL) were the same in all integrated subjects.

It should be noted that dissatisfaction with biochemistry among students was not higher than with physiology ($p<0.05$).

Based on this, the students were interviewed using the following questionnaire separately for each basic subject block (Blocks 1-4):

- Are you satisfied with the study of the specified block?

Probable answer - I am satisfied/I am not satisfied/I don't know/I find it difficult to answer.

Please explain your answer - if you are satisfied, why are you satisfied; If you are not satisfied, why are you not satisfied?

From the explanation given by the students, several important approaches were highlighted:
The material was presented primarily in the context of diseases, which made the learning process interesting.
The material was very difficult; there was a lot of it.
More clinical correlation would be desirable.
It would be desirable to discuss more clinical cases and more real-life examples.
Integration was very high.
More integration is desired; it was difficult to connect topics.
There was a lack of coordination.
Also, a small number of students indicated that it was difficult to answer.
Also, a small group of students did not explain the answer.

The obtained results are given in the table:

Question	Probable answer	Percentage of students who responded	Definition
Neuroscience	I am satisfied	29	The material was presented primarily in the context of diseases, which made the learning process interesting. Integration was very high. 6 students did not explain.
	I am not satisfied	3	I am not interested in these topics One student did not explain.
	I don't know/it's hard to answer	2	-
Body Function I	I am satisfied	21	We have studied topics in relation to diseases, which has increased interest in this subject. We have studied the biochemical basis of many diseases. 7 students did not explain.
	I am not satisfied	8	It is desirable to discuss more diseases. More integration is desired; it was difficult to connect topics. 3 students did not explain.
	I don't know/it's hard to answer	5	-
Body Function II	I am satisfied	20	The topics were discussed in relation to diseases, which made the subject particularly interesting. 6 students did not explain.
	I am not satisfied	10	More clinical correlation would be desirable. There was a lack of coordination. 4 students did not explain.
	I don't know/it's hard to answer	2	I am not interested in these topics.
Body Function III	I am satisfied	16	The material was related to diseases. All biochemical pathways were discussed with clinical correlates. The level of integration was very high, which allowed for a better understanding of the material. 3 students did not explain.
	I don't know/it's hard to answer	2	-

The number of students questioned N=30

Table 1: The Level of Satisfaction with the Basic Subject Blocks

As the analysis of the table shows, the high level of satisfaction of students in neuroscience is because all topics are closely related to diseases; in many cases, the part of biochemistry is completely devoted to discussing the biochemical basis of diseases such as Alzheimer's disease, Parkinson's disease, Huntington's disease, Amyotrophic Lateral Sclerosis, Epilepsy and Mechanisms of Antiseizure Drugs, Mood Disorders, etc. According to the students, this makes studying the topics very interesting. Dissatisfaction is mainly due to the lack of correlation between the material presented and relevant diseases, clinical cases, and real-life examples. Students also emphasised a high level of integration between subjects, which they believed facilitated understanding and mastery of the material. We consider this an important and positive aspect of the curriculum as the advancement of medicine is inseparable from the development of biochemistry. Much of modern medicine could not be practiced in its current form without an understanding of how genetic, pathogenic, and environmental factors influence the human body at the biochemical level. Therefore, the importance of teaching biochemistry to medical students is self-evident, as it provides a fundamental foundation for understanding disease mechanisms, interpreting clinical findings, and applying modern diagnostic and therapeutic approaches [17].

It is worth noting that to achieve a high degree of curricular integration, neuroscience is taught with neuroanatomy and histology. From our point of view, this integrated approach facilitates a more comprehensive understanding of the material by allowing students to connect the structural and functional aspects of the nervous system.

It should also be emphasized that education in the principles of neurology is essential for healthcare practitioners at all levels [22]. Furthermore, the introduction of neuroscience at the early stages of medical education can help students develop a strong foundation in ethical principles and promote a responsible patient-centred approach to clinical practice.

Current research suggests that compassion can be cultivated through education and training and is associated with positive emotions, a sense of affiliation, reward and prosocial behaviours. A compassion process model and framework, along with examples of educational goals, interventions, and resources for curriculum development, are described [23].

Students enrolled in the pilot neuroscience course performed significantly better ($p < 0.001$) on the examination than those who had completed the standard neurology course [24]. Innovative approaches have shown positive results. Medical University of South Carolina - neurosciences curricular innovation increased graduating student satisfaction scores and increased the number of students choosing careers in the clinical neurosciences. The model suggested by them may be a consideration for other medical schools that wish to integrate neuroscience teaching throughout their program [25].

However, an important question remains: Why is it necessary to study the basic sciences when physicians can rely on up-to-date guidelines and protocols in clinical practice?

The answer is as follows: In-depth mastery of the foundational sciences is important for preparing future physicians to meet the scientific advances that are rapidly transforming medical practice. [26].

A recent study conducted by the Association of American Medical Colleges and the Howard Hughes Medical Institute identified the foundational science competencies that physicians entering residency should possess to practice medicine grounded in scientific principles [27].

The importance of the natural sciences in medical education is now widely recognized; however, they should be presented in ways that help students recognize their relevance to medical practice. This relevance, together with clearly defined learning objectives, can provide valuable guidance to medical educators in presenting scientific concepts that prepare medical students to practice science-based medicine [26].

4. Conclusions

The students successfully passed the examinations in the integrated Physiology/Biochemistry modules and demonstrated active engagement throughout the learning process. They completed the assigned tasks and analytical activities successfully and actively participated in PBL sessions.

Physiology/Biochemistry are foundational/basic sciences that enable competent physicians to balance the art of medicine with rational, science-based medicine. It is important to the medical curriculum because these disciplines provide a fundamental basis for understanding and studying other foundational sciences. It teaches how scientific reasoning can be applied to clinical decision-making and provides a framework for solving clinical problems that require molecular insights. While Biochemistry is usually introduced in the first year of the medical curriculum, competency in applying biochemical principles to solve clinical problems is best achieved when these principles are vertically integrated throughout the four-year curriculum and presented within relevant clinical contexts using active-learning strategies [27].

The results will inform the planning and further development of the university's curriculum, providing valuable opportunities to modernize and update the content and topics covered.

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