

## *Original Article*

### Perspectives and Pedagogical Advancement in Biochemistry Education in Sudanese Medical Schools

Aisha Ibrahim. A. Omer<sup>1\*</sup>, Siham Mohamed Ahmed Bakhit<sup>1</sup>

<sup>1</sup> Department of medical Biochemistry, Faculty of medicine, Alzaiem Alazhari University, Khartoum Sudan

\* **Correspondence author:** Aisha Ibrahim. A. OMER, assistant professor, Department of medical Biochemistry, Faculty of medicine, Alzaiem Alazhari University, Khartoum Sudan.  
e-mail: [aisha.iao123@gmail.com](mailto:aisha.iao123@gmail.com)

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#### **Abstract**

**Background:** Medical biochemistry is a vital foundational subject in medical education. Sudan hosts quite a high number of medical schools, comprising 23% of Sub-Saharan Africa's and 10% of the Eastern Mediterranean Region's institutions. This study explores the perspectives of Sudanese biochemistry educators regarding curriculum structure, teaching approaches, topic sequencing, assessment methods, student feedback, and recommendations for improvement. **Methods:** A cross-sectional survey was conducted using a Google Form, targeting educators from 28 public (out of 33, representing 84.8%) and 12 private (out of 24, representing 50%) Sudanese medical schools. At least one public university from each state was included to ensure broad representation. The questionnaire assessed curriculum integration, instructional strategies, assessment methods, and educator qualifications. **Results:** The study covered 87% of public universities and private institutions in Khartoum State. An integrated curriculum was reported in 60.3% of schools, with strong horizontal and vertical integration. Approximately 50% (n = 29) of biochemistry educators held PhDs at the assistant or associate professor level. Lecture-based teaching, supplemented by problem-based learning (PBL), was common (77.6%), and 79.3% of respondents reported using both formative and summative assessments. While 72% of educators considered the biochemistry content in the curriculum sufficient, many advocated for better organization and sequencing of topics. Student feedback revealed that 77.6% of students found biochemistry difficult, with 13.8% perceiving it as a subject that relies heavily on memorization. A major concern identified was students' inadequate background in chemistry, reported by 74.1% of educators. **Conclusion:** Introducing a preparatory chemistry course is strongly recommended to address students' insufficient foundational knowledge. Additionally, promoting project-based learning, small group activities, and enhancing institutional support for educators in research and technology use are essential strategies to improve teaching effectiveness and student engagement in biochemistry.

**Keywords:** Biochemistry, Curriculum Integration, Medical Education, Pedagogy, Sudan.

## Introduction

Medical biochemistry plays a crucial role in demonstrating the practical applications of biochemistry in medicine, emphasizing understanding over memorization. The challenge lies in connecting medical biochemistry with clinical relevance and making it engaging for students (1). Curriculum reform is essential to motivate students to study biochemistry actively, rather than simply conveying advanced biochemical knowledge. Integrating biochemistry with clinical applications is vital for enhancing clinical practice skills and proficiency (2). This is particularly important as Sudan is considered among the countries hosting a high number of medical schools in Sub-Saharan Africa and the Eastern Mediterranean Region (3).

Typically, medical biochemistry education involves presenting factual information and discussing its medical significance, such as explaining disease pathology, diagnosis, drug development, metabolism, and patient care. However, some biochemical concepts do not readily apply to complex clinical cases, especially in the gray areas of conventional understanding (4). Even in introductory courses covering molecular structures and functions, many medical students and practitioners view biochemistry as an unnecessary burden. This raises the question of why biochemistry is perceived this way, and what educators can do to highlight its importance in medical education. Curriculum reform and updated teaching tools may help address these concerns.

Medical schools aim to produce doctors with sufficient understanding of biochemistry to apply it to clinical practice and medical advancements—not to create professional

biochemists (1). While most graduates are not expected to contribute to biochemical research, they should remain informed about advances in the field and recognize when biochemistry can contribute to clinical problem-solving.

Biochemistry educators, meanwhile, must balance maintaining subject integrity with ensuring its relevance within the broader medical curriculum. They are responsible for effectively communicating biochemical principles to both peers and students, while incorporating new scientific discoveries into their teaching. Implementing recommendations from organizations like the Nursing and Midwifery Council (NMC) in the UK—such as integrating biochemistry into Phases 2 and 3 of medical education—can enhance student knowledge, skills, and attitudes (5).

Factors contributing to the perception of biochemistry as burdensome include repetition of undergraduate content not relevant to Sudanese curricula, lack of contextual relevance to medical practice, and a significant disconnect from board exam content (1). Extensive reliance on memorization has also led to poor retention of knowledge. These challenges are largely related to curriculum content and delivery. Many educators believe that integrating biochemistry with clinical content could address these issues by emphasizing areas where biochemistry overlaps with clinical medicine. The ongoing debate focuses on whether fundamental principles should be taught traditionally through lectures or integrated into clinical cases using problem-based learning (PBL) or case-based learning (CBL). Research suggests that lecture-based

instruction often leads to rote memorization, poor academic performance, and poor retention (6).

Medical education has increasingly moved toward student-centered approaches, with PBL as a prominent example. However, implementing such strategies in biochemistry education requires careful planning. Biochemistry teaching has traditionally been lecture-based and information-heavy, with assessments focusing on factual recall through multiple-choice questions. Several studies have demonstrated that incorporating PBL and CBL improves comprehension, student satisfaction, and academic performance compared to traditional methods (7).

Evidence suggests that physicians trained under traditional, lecture-heavy models often lack clinical proficiency. Since the late 20th century, many countries have reformed medical education to embrace student-centered learning, including PBL, which originated at McMaster University in 1969 (8).

Dods (9) was among the first to incorporate PBL into biochemistry education, reporting more effective comprehension compared to traditional lectures. Rosing (10) noted greater satisfaction among students and instructors when PBL was used in clinical biochemistry. Anderson and colleagues (11) demonstrated improved standardized test scores and more positive student attitudes in an introductory biochemistry PBL course. Similar outcomes were achieved with CBL in advanced biochemistry education. Overall, CBL and PBL are associated with higher student satisfaction and lower failure rates (6).

In Sudan, medical schools adopt both traditional and innovative (integrated) curricula. The majority now rely on new

educational strategies, including PBL, community-oriented approaches, and integration of basic and clinical sciences (12). At Khartoum University, biochemistry evolved from being taught within physiology until 1959, when a dedicated biochemistry department was established. The current curriculum includes general molecular biochemistry for all students and specialized human biochemistry for medical students. Teaching methods include PBL, lectures, tutorials, seminars, problem-solving sessions, and practical laboratories featuring clinically relevant problems and case studies. Student evaluation involves midterm written examinations, practical assessments, and final examinations including written and oral components (13). This study aims to identify the teaching models of biochemistry used in Sudanese medical schools and analyze educator opinions regarding pedagogy, student feedback, student assessment, and the availability of practical sessions.

## Materials and Methods

This is a cross-sectional study involving all 28 public medical schools in Sudan, as well as 12 out of 24 private medical schools, representing 50% of the private sector. This resulted in a total sample of 40 medical schools.

### Participating public universities included:

University of Khartoum, University of Gezira, Omdurman Islamic University, University of Kassala, Red Sea University, Al-Managel University, University of Al-Fasher, Al-Neelain University, Sudan University of Science and Technology, University of Bahri, Alzaeim Alazhari University, El Geneina University, Dongola University, Al-Salam University, Karary University, Imam Al-Mahdi University, Shendi University, Sinnar University, Nile Valley University, Al-Butana University,

University of Kordofan, West Kordofan University, Abdulatif Al-Hamad University, Sheikh Abdalla Al-Badri University, Wadi Al-Neel University, El-Dalang University, Gadarif University, and Wadi Al-Neel Atbara.

**Private universities and colleges included:**

University of Medical Sciences and Technology, Ibn Sina University, Ahfad University for Women, Nile University, Al-Razi University, Al-Wataniya University for Science and Technical Studies, Napata College, International University of Africa, Al-Mughtaribeen University, Sudan International University, University of Science and Technology, and Zamzam

University. A structured questionnaire was developed using Google Forms. The questionnaire collected information on curriculum structure, teaching methodologies, integration approaches, and methods of student assessment. The study was conducted over seven months, from September 2022 to March 2023.

Responses were obtained from biochemistry educators using a 10-item questionnaire. Data were analyzed descriptively using frequencies and percentages, with Microsoft Excel used for processing and presentation.

Ethical approval for the study was obtained from the Faculty of Medicine at Alzaeim Alazhari University.

## Results

The questionnaire was distributed to 33 public schools, but due to non-response from Zalingei University, 32 schools were contacted and 28 responded, yielding an 87.5% response rate.

A total of 58 responses were collected from biochemistry educators regarding various aspects of biochemistry education in Sudanese medical schools. The academic ranks of these educators are shown in Figure 1.

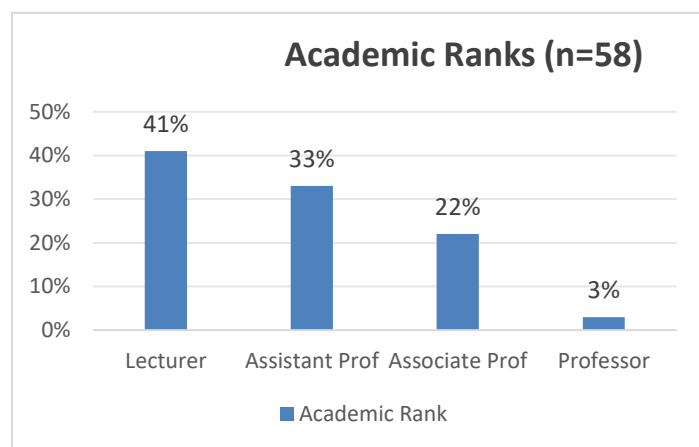


Figure 1: Academic ranks of the 58 educators of biochemistry who participated in the study

### Curriculum and Teaching Methods:

The percentage of biochemistry in Sudanese medical curricula was rated as fair by 72% of the respondents; while 17% thought it was too high and 10% thought it was too low. The survey revealed that 60.3% of respondents used an integrated curriculum, while 39.7% followed a traditional system. Among those using the integrated approach, 85.7% reported good horizontal integration across basic sciences, and 78.6% reported satisfactory vertical integration with clinical sciences.

A majority of educators (77.3%) used a combination of teaching methods, including PBL, while 23.6% relied mainly on lecture-based learning. About 73% believed that the

sequence of biochemistry topics facilitated student understanding, although 25% suggested reordering topics for better clarity.

### Perception of Biochemistry in the Curriculum:

Regarding the proportion of biochemistry in the curriculum, 72.4% of educators felt the allocated content was appropriate, while 17.2% considered it excessive, and 10.3% considered it insufficient. Educators noted that 77.6% of students found biochemistry difficult, with 13.8% perceiving it as overly dependent on memorization. Only 8.6% believed students found the subject easy. The Majority (74.%) of educators felt that an Introductory course in chemistry is needed.

### Assessment and Practical Teaching:

Most educators (79%) reported using both formative and summative assessment methods. However, only 36.2% reported implementing a defined minimum pass level for student evaluations (Figure 2). Regarding practical biochemistry, 72.7% reported that laboratory experiments were available or partially available, while 27.3% reported limited or no access to practical sessions.

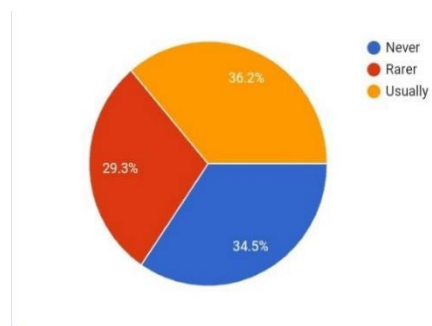


Figure (2) Using minimum pass level in the exam

### Suggestions for Improving Biochemistry Teaching:

Respondents suggested several strategies to improve biochemistry education, including:

- Revising and updating the curriculum to better integrate basic sciences with clinical practice.
- Incorporating diverse teaching methods, including PBL and interactive lectures.

- Using modern technology such as videos and digital tools to simplify complex concepts.
- Enhancing relevance by linking topics to clinical applications.
- Hiring qualified teaching staff and offering continuous professional development.
- Introducing foundational chemistry courses for first-year students.
- Emphasizing specialized tissue-related biochemistry topics.

These recommendations aim to make biochemistry more engaging, clinically relevant, and accessible to medical students.

### Discussion

Undergraduate Medical Education (UME) in Sudan dates back to 1924 with the establishment of the first medical school. Today, Sudan has approximately 66 medical schools (14), making its medical education system one of the oldest in the region (15). Notably, Sudan accounts for around 23% of all medical schools in Sub-Saharan Africa and 10% in the EMRO region (3). However, published literature from Sudan constitutes only about 2% of medical education reporting from Sub-Saharan Africa (14). In 1970, the Educational Development Centre was established to further enhance the educational landscape [(15). The national initiative termed "Revolution in Higher Education" was launched in the early 1990s aiming to expand Sudan's university network to meet the growing population's needs (16). This was to address the unequal distribution of doctors nationwide by recruiting students from various states and encouraging them to serve in their home regions after graduation (14). As a result, medical graduate numbers increased from approximately 600 per year in 1990 to about 5,000 per year by 2006. Over 15 years, the number of medical schools grew sevenfold, reaching 30 institutions. Today,

Sudan has over 72 medical schools, with 65% located in Khartoum and Gezira, these being the most densely populated states (14).

Recognizing the importance of educational quality, the International Union of Biochemistry and Molecular Biology expressed interest in this study. Our research covered 87% of government universities, ensuring representation from all regions of Sudan. The survey focused on curriculum structure and teaching methodologies. It is important to note that innovative teaching strategies succeed only when integrated effectively into the overall curriculum (17). Educators must also continuously update their knowledge to keep pace with rapid advances in medical biochemistry, including the integration of molecular diagnostics, proteomics, laboratory information systems, and related technologies (18).

Our study reveals that Sudanese medical schools prioritize curriculum development and review, resulting in programs that incorporate modern educational tools. Integrated curricula were dominant (60%). Most educators reported satisfactory horizontal integration among basic sciences and vertical integration with clinical sciences. Although the shortage of senior faculty was apparent, 54.5% of respondents held doctoral degrees.

Teaching biochemistry remains challenging, particularly in engaging students with complex topics like metabolism and biochemical pathways (19). In our study, 78% of students found biochemistry difficult, while 14% viewed it as primarily reliant on memorization. Globally, medical education is shifting toward student-centered, problem-based, and case-based curricula to encourage active participation and self-directed learning (20). In Sudan, 78% of medical schools employ both lectures and PBL, while 22%

still rely exclusively on lectures. International experiences, such as the hybrid PBL program at Dalian Medical University, highlight the benefits of such approaches in biochemistry education (2).

Regarding curriculum content, most educators (72%) believed the proportion of biochemistry in the curriculum was appropriate.

Basic science knowledge strongly influences students' performance in PBL courses. In our study, 74% of respondents recommended introducing a foundational chemistry course to support biochemistry learning.

Assessment practices varied: 79% of educators used both formative and summative assessments. Regarding the application of a defined minimum pass level, only over a third (36%) reported using it. In terms of practical biochemistry teaching, 22% indicated full availability, while 55% of educators reported partial access to laboratory experiments. These findings highlight the need to invest in infrastructure and materials for laboratory-based education.

To keep pace with advances in personalized medicine and molecular biology, medical biochemistry educators must prioritize continuous professional development and technological updates (18).

## Conclusion

This study reveals that the integrated curriculum is widely adopted in Sudanese medical schools, characterized by strong horizontal integration among basic sciences and effective vertical integration with clinical sciences. Teaching methods predominantly combine lectures with problem-based learning (PBL), creating a balanced pedagogical approach. Furthermore, 79% of

educators reported using both formative and summative assessments. To enhance biochemistry education, medical schools should consider revising curricula to improve topic sequencing, invest in faculty development, and promote innovative, interactive teaching methods that foster deeper understanding and better integration of biochemistry within the broader medical education framework.

## Recommendations

1. **Introduce a foundational chemistry course** to strengthen students' understanding of medical biochemistry.
2. **Promote student-centered teaching approaches**, including PBL and small group discussions, to enhance engagement and comprehension.
3. **Support faculty development** through structured training programs and research opportunities to improve teaching effectiveness and academic qualifications.

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## References

1. Afshar MA, Han Z. Teaching and learning medical biochemistry:

- perspectives from students and educator. *Med Sci Educ.* 2014;24:339–41.
2. Qiu Y, Lima L, Zhu L, Zhang W. Learning effectiveness and satisfaction of international medical students introducing a hybrid-PBL curriculum in biochemistry. *IUBMB Life.* 2017;45(4).
3. Abdalla M, Suliman RA. Overview of medical schools in the Eastern Mediterranean Region of the World Health Organization. *East Mediterr Health J.* 2013;19(12):1020–5. <http://dx.doi.org/10.26719/2013.19.12.1020>
4. Josha MJ, Dudum R, Maguilies SL, Mehat A, Han Z. Problem-based teaching and learning of medical biochemistry according to clinical realities: a case study. *IUBMB Life.* 2016;44(1):95–8.
5. Dandekar SP, Mahdi F, Chacko TV. A critical appraisal of the new competency-based medical undergraduate curriculum in biochemistry. *Indian J Clin Biochem.* 2022. <https://doi.org/10.1007/s12291-022-01088-y>
6. Alexandre B, Passos RM, Ono AH, Hermes-Lima M. The use of multiple tools for teaching medical biochemistry. *Adv Physiol Educ.* 2008;32:38–46.
7. Kulak V, Newtown G. A guide to using case-based learning in biochemistry education. Wiley Online Library. 2014 Oct.
8. Jaleel A, Rahman MA, Huda N. Problem-based learning in biochemistry at Ziauddin Medical University, Karachi, Pakistan. *Biochem Mol Biol Educ.* 2001;29:80–4.
9. Dods RF. A problem-based learning design for teaching biochemistry. *J Chem Educ.* 1996;73(3):225. <https://doi.org/10.1021/ed073p225>
10. Rosing J. Teaching biochemistry in a medical faculty with a problem-based learning system. *Biochem Educ.* 1997;25(2):71–4.
11. Osgood MP, Mitchell SM, Anderson WL. Teachers as learners in a cooperative learning biochemistry class. *Biochem Mol Biol Educ.* 2005;33(6):394–8.
12. Ahmed AM. Medical education in Sudan: emerging issue and acute need. *Sudan J Public Health.* 2012;7(2):56–64.
13. Dafallah AA. Biochemistry in Khartoum. *Biochem Educ.* 1992;20(1):23–4.
14. Ahmed AAH, Eltahir SEA, Alabass SOA, Osman FHM. The ravages of war: challenges and resilience in medical education in Sudan. *Educ Health.* 2024;37(3). <https://doi.org/10.62694/efh.2024.154>
15. Kronfol N. Historical development of health professions' education in the Arab world. *East Mediterr Health J.* 2012;18(11):1157–65. <http://dx.doi.org/10.26719/2012.18.11.1157>
16. Gasim G. Reflecting on Sudan's higher education revolution under Al-Bashir's regime. *J Comp Int High Educ.* 2010;2:50–3.
17. Huang PC. The integrative nature of



- biochemistry: challenges of biochemical education in the USA. *Biochem Educ.* 2000;28:64–70.
18. Biswas SK, Choudhury S. The scope and challenges of medical biochemistry. *Bangladesh J Med Biochem.* 2016;9(1):3–4.
  19. Chen H, Ni JH. Teaching arrangement of carbohydrate metabolism in biochemistry curriculum in Peking University Health Science Center. *Wiley Online Library.* 2013 May.
  20. Patil VP, Patil VS, Kulkarni SP, Trivedi DJ, Axita VC, Mudaraddi RT, et al. Case-based learning in biochemistry: an innovative criterion-based assessment module for effective learning among MBBS Phase 1 students in India. *Indian J Med Biochem.* 2017;21(1):62–8.