



# A Critical Appraisal of the New Competency-Based Medical Undergraduate Curriculum in Biochemistry

Sucheta P. Dandekar<sup>1</sup> · Farzana Mahdi<sup>2</sup> · Thomas V. Chacko<sup>3</sup>

Received: 25 April 2022 / Accepted: 2 September 2022 / Published online: 10 November 2022  
© The Author(s), under exclusive licence to Association of Clinical Biochemists of India 2022

## Abstract

The new competency-based medical education undergraduate curriculum (CBMC) was launched for the 2019 admission batch of MBBS students. The programme is designed to create an “Indian Medical Graduate” (IMG) possessing the requisite knowledge, skills, attitudes, values and responsiveness, so that the graduate may function appropriately and effectively as a physician of first contact with the community while being globally relevant. Given that implementation of this curriculum is still in its infancy across the country, we stand to gain from a unified approach to its implementation. Phase I of the curriculum includes anatomy, physiology, and biochemistry along with professional and personal development modules. Biochemistry enjoys an enviable position in the medical curriculum as it explains the molecular basis of diseases. We present an appraisal of the curriculum in Biochemistry by reviewing the components against Harden’s six themes which are considered when planning or developing a curriculum. Further, five core components of CBME are selected on the basis of three research papers to characterize underlying assumptions of CBME to suggest ways of logical implementation for achieving the competencies expected of the Indian Medical Graduate. The insight gained shall help students to be equipped with competencies which they

shall be able to use in their day- to- day work, which shall ultimately help benefit patient care and the society at large.

**Keywords** Competency based medical education · curriculum · biochemistry · undergraduate Indian Medical Graduate

## Context that Necessitates the Review

The “traditional” undergraduate medical curriculum in India had remained discipline-based education, teacher centered, with a focus on knowledge acquisition and single time, summative assessments. The system relied heavily on didactic lectures. Assessments were also largely based on recall of factual information and honing of skills which were becoming redundant, especially in the subject of Biochemistry.

Constituted by an act of Parliament, known as the National Medical Commission Act, 2019, the National Medical Commission (NMC), came into force by a gazette notification dated September 24, 2020. The NMC placed “Minimum requirements for annual MBBS admissions regulations, 2020,” in the public domain on October 28, 2020. [1] The main aim of the NMC is to improve access to quality and affordable medical care; ensure the availability of adequate and high-quality medical professionals in all parts of the country.[2].

“Competency Based Undergraduate Curriculum for the Indian Medical Graduate” was launched for the 2019 admission batch of MBBS students. This document highlights the required competencies and the appropriate teaching-learning activities.[3].

Competency-Based Medical Education (CBME) is an outcome-based strategy that integrates knowledge, skills, attitudes, and ethics into observable and measurable competencies.[4] Faculty development was envisaged as a key determinant for the successful implementation of the CBMC. Training of medical teachers through the basic and

✉ Sucheta P. Dandekar  
sucheta.dandekar@gmail.com

Farzana Mahdi  
farzana.mahdi@gmail.com

Thomas V. Chacko  
chackotv@bcmch.edu.in

<sup>1</sup> Era University, Era’s Lucknow Medical College, Sarfaraz Ganj, Hardoi Road, 226003 Lucknow, Uttar Pradesh, India

<sup>2</sup> Era University, Era’s Lucknow Medical College, Sarfaraz Ganj, Hardoi Road, 226003 Lucknow, Uttar Pradesh, India

<sup>3</sup> Believers Church Medical College & Hospital, St Thomas Nagar, 689103 Kuttapuzha, Thiruvalla, Kerala, India

advanced course workshops via the curriculum implementation support program (CISP), contributed to the capacity building of the faculty.[5].

The expertise of local healthcare faculty to guide meaningful standardization and meet the local needs of educational programs should be inculcated. As a guideline, the five core components of CBME should serve to ensure and maintain the fidelity of the original design of outcomes-based education during the implementation of the Biochemistry curriculum, along with the review the new curriculum against Harden's conceptualization of various components of the curriculum.[6, 7].

The goal of CBME is to produce an Indian Medical Graduate (IMG) who is envisaged as a doctor fulfilling the roles of clinician, leader, communicator, professional and lifelong learner.[3] Biochemistry enjoys an enviable position in the medical curriculum. Biochemistry explains the molecular basis of diseases. A lot of medicine is based on Biochemistry and a total of 250 h of Biochemistry teaching are advocated in the curriculum.[8] How the curriculum of biochemistry shall influence the achievement of the overall goals of the IMG curriculum at national and individual levels remains to be seen.

The initial authors of the curriculum of Biochemistry had mostly listed the content and traditional teaching of Biochemistry into outcome competencies. While this is a step forward, one of the advantages of CBME where curricular outcomes are in alignment with job roles and making them "job ready" is not made clear. One of the risks is a lot of cognitive overload and a burden on the students. Hence, we aimed to do this alignment so that essential elements are not missed and at the same time some relatively 'not directly contributing to job roles' is got rid of, thereby, reducing the cognitive burden on the students. In the traditional curriculum, this was increasing with no "shedding" of obsolete or unrelated facts.

Table 1 showcases the competencies for the goals of IMG and the role of Biochemists to help fulfil them as envisioned by the authors. There are 35 competencies defined for these five roles. The teaching-learning strategies elaborated in the table for Biochemists should be implemented with the spirit in which it is stated, keeping in mind the five roles of the IMG, ensuring that the modules developed have reference to them.[9]

It is evident here that the ECE, AETCOM and small group teaching methods shall help instil a foundation for the complete execution of the 5 roles of the IMG.

- \*Clarifications regarding the role of biochemists --- at phase 1 biochemists should refrain from expecting the students to diagnose disease, ability to do differential diagnoses or know the normal values of biochemical test

parameters. Integration is the need of the hour and the complexities of the disease with inputs from Biochemistry should be pursued at the phase 3 levels. The main role in phase 1 is the introduction of the normal and a clear cut early clinical exposure with no references to complex diseases.[6, 10–13].

- Dongre and Chacko have examined the new competency-based undergraduate curriculum document in community medicine using established frameworks and criteria to identify possible gaps in content and alignment.[14] The paper suggests that it can be used by other disciplines to work out the gaps. Therefore, we shall now review the components of the new curriculum against Harden's conceptualization of various components of the curriculum.[7].

### Individual Components of Undergraduate Curriculum w.r.t. Biochemistry

Harden suggested that the curriculum should contain the following components – learning outcomes, content, educational strategies, learning opportunities, assessment, and educational environment.[7] Curriculum development is a dynamic process. Any changes made in any of the components shall elicit changes in the other components as well.

### Stated Learning Outcomes

The National Medical Commission UG curriculum document encompasses a wide range of contents from teaching, learning, assessment and integration. The teaching-learning methods recommended in Biochemistry have 11 topics with 89 competencies. Each medical college / University was encouraged to write their specific learning objectives (SLOs) to be derived from the listed outcome competencies and our university has come up with as many as 295 SLOs in biochemistry.

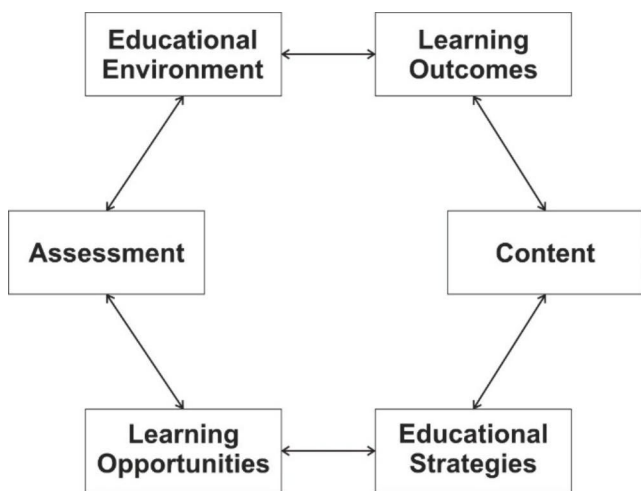
Keeping in mind the job roles of IMG and the exception to practice Evidence-Based Medicine, the application of knowledge of Biochemistry (higher cognitive domains of Bloom's Taxonomy) is expected by the product of the graduate curriculum and hence the need for a listing of higher cognitive domain outcomes. However, in the existing curriculum document review, it is observed that 89 outcome competencies are at a lower order of Bloom's Taxonomy (34 describe, 8 explain, 17 discuss, 1 define, 2 enumerate, 11 demonstrate, 4 observe, 1 differentiate, 1 outline, 1 perform, 1 identify, 3 calculate and 5 interpret) and this has led individual institutions that followed the CISP process guidelines to the formulation of lower end SLOs as well.

**Table 1** Relationship between the competencies for the roles of IMG and the role of Biochemists

Role	Description	Competency with a role for Biochemists*	How Biochemistry can help achieve this
Clinician	Who understands and provides preventive, promotive, curative, palliative and holistic care with compassion	3.1.1 Demonstrate knowledge of normal human structure, function and development from a molecular, cellular, biologic, clinical, behavioural and social perspective. 3.1.2. Demonstrate knowledge of abnormal human structure, function and development from a molecular, cellular, biological, clinical, behavioural and social perspective. 3.1.6. Demonstrate ability to elicit and record from the patient, and other relevant sources including relatives and caregivers, a history that is contextual to gender, age, vulnerability, social and economic status, patient preferences, beliefs and values. 3.1.11 Demonstrate ability to choose the appropriate diagnostic tests and interpret these tests based on scientific validity, cost-effectiveness and clinical context 3.1.15 Demonstrate familiarity with basic, clinical and translational research as it applies to the care of the patient.	As per SLOs of each competency Early Clinical Exposure (ECE), case-based teaching, Attitude Ethics & Communication (AETCOM) ECE, case-based learning Skills lab and hands-on lab setting, economics, AETCOM, ECE cases should emphasize the costs of tests and their utility concerning affordability. Electives, short term research project
Leader and member of the health care team	Ability to take everyone along to deliver the outcome in a time-bound manner more efficiently and effectively with capabilities to collect, analyze, synthesize, and communicate health data appropriately	3.2.1 Work effectively and appropriately with colleagues in an inter-professional health care team respecting the diversity of roles, responsibilities and competencies of other professionals. 3.2.2 Recognize and function effectively, responsibly and appropriately as a healthcare team leader in primary and secondary healthcare settings. 3.2.6 Recognize and advocate health promotion, disease prevention and healthcare quality improvement through prevention and early recognition: in (a) lifestyle diseases and (b) cancer, in collaboration with other members of the health care team.	Importance of teamwork in lab Community lab, rural set-up, point of care testing devices, socio-economic status, demography. Basic biochemical principles are to be reiterated in phase 3. Nutritional aspects and molecular biology
Communicator	With patients, their families, colleagues, community and political leaders to influence by providing evidence-based interventions	3.3.1 Demonstrate ability to communicate adequately, sensitively, effectively and respectfully with patients in a language that the patient understands and in a manner that will improve patient satisfaction and health care outcomes. 3.3.2 Demonstrate ability to establish professional relationships with patients and families that are positive, understanding, humane, ethical, empathetic, and trustworthy. 3.3.3 Demonstrate ability to communicate with patients in a manner respectful of patients' preferences, values, prior experience, beliefs, confidentiality and privacy.	Foundation course Role plays, ECE, AETCOM. Communication skills Cultural diversity and inclusivity. Case-based learning, ECE
Lifelong learner	With a commitment to the continuous improvement of skills and knowledge as per the change in medical technologies and epidemiological shift	3.4.1. Demonstrate ability to perform an objective self-assessment of knowledge and skills, continue learning, refine existing skills and acquire new skills. 3.4.4. Demonstrate ability to search (including through electronic means), critically evaluate the medical literature and apply the information in the care of the patient. 3.4.5. Be able to identify and select an appropriate career pathway that is professionally rewarding and personally fulfilling.	Self Directed Learning (SDL), ECE SDL, Electives End of Practical Reflections & Reflective writing & logbooks to appreciate the importance of Biochemistry as a career; Offer Electives
Professional	Who is committed to excellence, ethical, responsive and accountable to patients, the community, and the profession	3.5.1. Practice selflessness, integrity, responsibility, accountability and respect. 3.5.2. Respect and maintain professional boundaries between patients, colleagues and society	Foundation course, ECE, AETCOM Foundation course, ECE, AETCOM

Apart from knowledge, the curriculum embraces other components as well such as skills, attitudes and communication. Of the 89 outcome competencies in Biochemistry, only 11 are 'skills', and the rest are all related to the knowledge

domain. This needs to be rectified as there are many competencies in Biochemistry where attitude and communication need to be included and specified. The core competencies required of a medical graduate are predetermined in the



**Fig. 1** Curriculum components according to Harden.[7]

curriculum. Surprisingly, the entire curriculum has been

placed as core and only 1 competency—‘ describe protein targeting & sorting along with its associated disorders’ is designated as non-core.

A review is carried out involving six heads ie.learning outcomes, course content,educational strategy,educational environment,learning opportunities and experience,assessment. These components of the curriculum are discussed.

## Course Content

Knowledge, skills and attitude have to be defined as part of the content. Though the knowledge and skills components find a place in the curriculum, attitude and communication are missing. The extent of Biochemistry to be taught to undergraduate medical students has been a focal point in medical curriculum development. Strengths and weaknesses

**Table 2** Guiding principles to support the implementation of CBME Biochemistry tied to characteristics of CBME as identified by Frank et al.s<sup>37</sup>[37] Competency-based medical education: theory to practice, Holmboe et al. s<sup>39</sup>[39] A call to action, and Van Melle et al.s<sup>40</sup>[40] A core components framework. (2019). (Modified from Table 1[6].)

Guiding Principles for the implementation of CBME Biochemistry	Characteristics of CBME per Frank et al. [37]	Characteristics of CBME per Holmboe et al. [38, 39]	Characteristics of CBME per Van Melle et al.[40]
1. Core competencies in Biochemistry were identified. Institutions worked on specific learning objectives. (NMC documents). 11 domains with 89 competencies in Biochemistry specified. Need to correlate with the roles of IMG.	Identify the abilities needed by graduates A focus on curricular outcomes.	Outcomes in the form of pre-defined competencies.	Clear articulation of outcome competencies.
2. Teaching should be aligned to the outcomes and to the stages. Biochemistry is in the pre-clinical phase, learning sequences in a horizontal and vertical integrated manner. The curriculum continues to be knowledge-based unless motivated faculty help to raise the bar.	An emphasis on abilities (a hierarchy of competencies as the organizing principle of curricula). Emphasis on skills and attitude	Competencies are aligned with the roles graduates will play. Pre-defined competencies are derived from the needs of patients, learners, and institutions and are organized into a coherent guiding framework	Progressive sequencing of competencies and their developmental markers
3. Expectations of performance criteria have to be set (milestones), use of entrustable professional activities (EPAs) is recommended, though not in place still.	A de-emphasis of time-based training.	Time is a resource for learning, not the basis of progression of competence (e.g. time spent on a ward is not the marker of achievement). Learning is tailored in some manner to each learner’s progression.	Competency-Focused instruction.
4. Learner centeredness is emphasized with the honing of self-directed learning, and interactive teaching-learning methods. Faculty and student training for successful implementation. Skills training in relevant biochemistry competencies.	The promotion of learner-centredness Select educational activities, experiences, and instructional methods.	Teaching and learning experiences are sequenced to facilitate an explicitly defined progression of ability in stages.	Tailored learning experiences
5. Introduction of case-based questions, clinical vignette-based MCQs. Modified essay questions, Objective Structured Practical Examination (OSPE). Programmatic Assessment is associated with partnerships between the learner and the assessor based on the sharing of formative, coaching feedback that allows the learner to gauge their progress toward competence Each department to undertake an evaluation of the program w.r.t their institution.	Select assessment tools to measure progress along with the milestones. Design and outcomes evaluation of the program	Numerous direct observations and focused feedback contribute to effective learner development of expertise. Assessment is planned, systematic, systemic, and integrative.	Programmatic Assessment

in the traditional practical curriculum have been identified to develop strategies to improve the curriculum. There have been studies that critically appraise, and have made suggestions for modifications and implementation of the laboratory-based curriculum for undergraduates. [15–17]

Khromova and Gray have stated that the doctors do need to understand the relevance of clinical biochemistry tests, which would help them with patient care.[18] The study has suggested that an online tutorial could be a useful adjunct to clinical biochemistry teaching. This seems to be more relevant in the present trying times of dealing with the pandemic.[19, 20].

The organization of the content is discipline-based. Most of the content remains the same as per the traditional curriculum. In order to execute the content in the spirit in which it is intended, faculty development workshops, including the faculty of the disciplines of the integration modules could perhaps help. The skills list in the Biochemistry curriculum are lop-sided. The last competency (BI 11) in the curriculum is dedicated to Biochemistry laboratory tests. There are 24 competencies and 11 skills specified—9 to be performed and 2 are ‘shows how’. Of these skills, 5 are certifiable skills and all have to be practised once! Also, there is a surprise addition of ‘observe the estimation of SGOT and SGPT’ as competency 2.2 under the topic of enzymes. The domain is knowledge, the level is ‘knows’ and the assessment suggested is ‘viva voce’! An analysis of the content has revealed the following discrepancies which could be sorted out in the next curriculum revision.

- BI 3.2 and BI 3.3 are repeated. BI 3.5 is to be shifted after BI 3.7.
- Interchange competencies BI 4.3 and BI 4.4. BI 4.5 and BI 4.7 are repeated.
- BI 6.9 and BI 6.10 can be merged.
- BI 7.5 – BI 7.7 are not molecular biology topics. These topics could be included in topic 6.
- BI 11.3, 11.4 and 11.20 can be clubbed.
- BI 11.7, 11.8 and 11.22 can be clubbed.
- BI 11.21 only urea to be included as the other parameters are repeats.

BI 11.4 states ‘perform urine analysis to estimate and determine normal and abnormal constituents’ and are a certifiable skill whereas BI 11.21 states ‘Identify abnormal constituents in urine, interpret the findings and correlate these with pathological states’, which is also a certifiable skill. This needs rectification. The addition of several procedural skills in Biochemistry is undesirable, as the IMG is never going to perform them.[21] ‘Students should know that laboratory tests can be used for multiple clinical purposes: screening, risk assessment, the establishment of a diagnosis, support

of a diagnosis, exclusion of a diagnosis, prognosis, determination of individualized therapy, and assessment of disease progression or response to therapy. They should understand the differences in interpretation that these settings require and that laboratory tests must be interpreted in conjunction with the entire clinical presentation. They should be able to order not only all of the tests necessary in a particular clinical setting but also only the tests that are medically useful for their patients’. This calls for additions in the curriculum to highlight these aspects or to include some parts as electives.[22] This shall be discussed later on in detail in this paper.

## Educational Strategies

The Fundamental Teaching Activities (FTA) Framework describes activities that can be undertaken by teachers in competency-based medical education programs. It describes a Clinical Preceptor domain which is divided into two separate tasks. The Clinical Coach is needed to carry out day to day teaching activities with the introduction of clinical reasoning, appropriate feedback and assessment. The role of the Competency Coach is to develop learning plans and guide the overall professional development of the learner. Another domain, Teachers Outside the Clinical Setting, encompasses teaching-learning strategies and encourages the teacher to work on before, during and after the teaching session. The sessions can be related to small groups, large groups, online or hybrid ones. As the CBME gets implemented, the framework also highlights the role of the teacher in curriculum development, administration and faculty development. The Educational Leader, Programmer and Administrator are the roles that are defined. Teachers may be engaged in one of these tasks only, or maybe active in both.[23] The full FTA Framework is available online at [www.cfpc.ca/FTA](http://www.cfpc.ca/FTA) and is worth a study to implement as day-to-day strategies by all disciplines.[23].

CBME is learner-centred and encourages self-directed learning. There are 20 h of self-directed learning in Biochemistry that have to be incorporated into the timetable. Lecture, small group teaching, practicals and demonstrate, observe, assess and perform (DOAP) are the only teaching-learning strategies indicated. The lectures should not exceed 1/3 of the total schedule. Learner-centred modalities such as flipped classroom, case-based teaching, jigsaw, role-plays etc. can be added. A coordinated approach with multiple teaching tools such as Group-Based Learning (GBL), Video-Based Learning (VBL), and Case-Based Learning (CBL) are good methods for effectively teaching biochemistry.[9].

Suneja et al. mention the use of online resources adopted. E-learning tools were utilized to engage first-year undergraduate students and satisfy a majority of aspects of Competency-Based Undergraduate Medical Curriculum/Education (CBMC/E) in Biochemistry. [9] They incorporated the use of Microsoft Teams as a Learning Management System (LMS) for teaching, learning, and assessment module in biochemistry. Though these strategies are illustrated to cope with the pandemic, these can be continued to be used in face-to-face situations.

Dongre and Chacko have suggested the inclusion of methods to facilitate the acquiring of competencies for teamwork, leadership and program management --- competencies to make the IMG job-ready to work in primary care settings which are also apt for biochemists in the laboratory and will serve as a stepping stone for the later years. [14].

Alignment of topics in the same phase (horizontal) and integration of topics from different phases (vertical) are identified. For Biochemistry, horizontal integration is advocated for 13 topics in Physiology, 3 topics in Anatomy and 3 topics in both Physiology and Anatomy. Vertical integration includes 20 topics in Pathology, 45 in General medicine, 8 in Paediatrics, 1 in Microbiology, 3 in General Surgery, 1 in Community Medicine and 3 in Obstetrics and Gynaecology leading to a total of 81 topics. Care has to be taken while devising the timetable to incorporate these strategies. Consultations with the various departments should be enough to take the topic forward in most cases. The physical presence of each department faculty member may not be possible always.

The departments can decide to formulate “linker cases” with the concerned department. E.g. A case of iron deficiency anaemia can be introduced by Physiology when they teach the topic of different types of anaemias. Then Biochemistry the serum iron values, iron-binding capacity and serum ferritin can be added along with the normal values. This same case can be built on later by the Pathology, Pharmacology, Community Medicine and General medicine departments.[24].

## Learning Opportunities and Experiences

New curricular elements introduced, include the foundation course (FC), early clinical exposure (ECE), attitudes, ethics and communication (AETCOM), self-directed learning (SDL), elective postings (EP), skill training, clinical clerkships, the pandemic module and the family adoption program. Incorporation of structured feedback, writing reflections and maintenance of logbooks are other notable features of the CBME.[1].

The foundation course, to be introduced in the first month of phase 1 is meant to familiarise the students with the teaching program, communication skills, time management, enhancement of language and computer skills, national programs, stress management, field visits, as well as sports and extracurricular activities. The three departments of Anatomy, Physiology and Biochemistry plan the related activities.

Early clinical exposure, a step to rationally linking the theory of basic science to clinical practice, is a teaching and learning methodology that emphasizes the exposure of medical students to patients in classroom, hospital or community settings. In the classroom setting, patients can be brought to the classroom or paper cases can be discussed. In the hospital setting ward, clinic or laboratory visits are included. This is very important for the Biochemistry department. A case can be discussed in the ward in small groups and the same batch of students can be taken for a laboratory visit to showcase the generation of laboratory reports. The community setting may include a primary health centre or community visits. An overview of the society and understanding of the health needs of a given population can be introduced along with the use of point of care devices (glucometer), other simple qualitative tests (glucose, protein) can be discussed here. 30 h are allocated for Biochemistry, 18 h for basic sciences and 12 h for clinical modules. So, 6 basic science modules and 4 clinical modules have to be planned. Assessment is also ingrained in this module and humanities, ethics, and communication skills have to be intertwined in the case.

These are the modules that will be covered in the First MBBS as part of the AETCOM.

Module 1.1: What does it mean to be a doctor? No assessment is advocated.

Module 1.2: What does it mean to be a patient? Internal assessment—participation in group discussion. Final examination ---Short answer questions (SAQs) may be asked.

Module 1.3: The doctor-patient relationship. Internal assessment – critique of case discussions and final examination—SAQs on rights and responsibilities of patients, boundaries of the doctor-patient relationship.

Module 1.4: The foundations of communication –1. Internal assessment –case discussion. No question in the final examination except for empathy etc. in applied questions.

Module 1.5: The cadaver as our first teacher. Internal assessment –active participation. No assessment in the final examination.

All the modules will be a part of the internal assessment and 1 question or sub-question could be asked in the final examination related to communication in Biochemistry i.e. modules 1.3 and 1.4. invariably, modules 1.1 and 1.2 are

dealt with by Physiology, and 1.5 by Anatomy. Of course, this could differ with each college.

The AETCOM principles can be incorporated into the applied questions that are asked in theory. They should be also added to the practicals when case discussion and interpretation of Biochemistry laboratory results ensue.

Two hours for the history of outbreaks, epidemics and pandemics, are dedicated to the pandemic module as part of the foundation course and are the responsibility of the pre-clinical phase. Clinical skills laboratory establishment shall involve the departments of Biochemistry in Phase I and by departments of Pathology in Phase II for skills training such as phlebotomy, and quality management of biochemical parameters for biochemistry departments. Five families, from areas not covered by the public health centre, shall be introduced to each student in Phase I. Though Community Medicine will be involved, the pre-clinical phase shall incorporate into the timetable.

The electives module in basic sciences encourages students to participate in the basic sciences laboratory or join ongoing research programs. Biochemistry departments with their rich material and programs available can play an important role. Applications to various scholarship funds can be made by the faculty.[25].

## Assessment System

Assessment is without any doubt an essential element in every curriculum. There are two types of assessment practices advised in the CBC --- formative and summative. In the new CBME curriculum paradigm, the focus of assessment has shifted from summative assessment to formative assessment to facilitate the acquisition of stated outcomes. Assessment methods that rely on the ability of the students to recall like essays, short notes, MCQs should give way to the newer ways of using a combination of various types of questions e.g. structured essays (Long Answer Questions - LAQ), Short Answers Questions (SAQ) and objective type questions (e.g. Multiple Choice Questions - MCQ). Marks for each part should be indicated separately. MCQs if used, should not have more than 20% weightage. The phase I paper suggests that ECE assessment should be included subject wise, and this could be used as formative assessment. There should be at least one short question from AETCOM in each subject and one of the 3 tests in preclinical subjects should be prelim or pre-university examination.[26-28]

The competency-based undergraduate curriculum stresses objectivity, uniformity, validity and reliability of the assessment tools since assessment drives learning. Conventional Practical Examination (CPE) in Biochemistry is subjective and associated with examiner variability and raises

concerns over its validity and reliability. Objective Structured Practical Examination (OSPE) addresses this problem as it includes objective testing through direct observation, assessment of knowledge, comprehension and skills.

Clinical case studies and assessments devised related to them, help remind students that what they are learning has relevance in the real world, and may help motivate students to pay more attention to the numerous facts faced in biochemistry. [29, 30]

Traditional assessment methods of written theory and practical examinations should move into the setting of structured essays, deconstructed scenarios like OSCE or OSPE and workplace-based assessments (WPBA) such as the mini-CEX or direct observation procedural skills (DOPS) methods. Maintenance of logbooks which can be developed into portfolios, incorporating reflective thinking and narratives is advocated. Needless to say, the faculty have to be trained not only to conduct the new assessment methods but also to give feedback and mentor the learners. Direct observation of students with appropriate feedback strategies to help improve the utility of competency-based assessment, along with multiple assessors, multiple tools and multiple assessments to improve the validity and reliability of competency-based assessment have been suggested in the NMC module.

It is left to the departments to introduce the newer assessment methods. This leaves the system wanting to be dedicated, motivated stakeholders who understand the nuances of CBME and take it upon themselves to introduce, validate and evaluate the systems. Sharing best practices and collaboration with resource-rich and more experienced institutions to address faculty development is in line. This leads us to discuss Harden's sixth and final theme of the environment. [27, 31]

## Educational Environment

An educational environment is composed of the physical environment as well as the emotional and intellectual climates. It refers to various physical sets, contexts, and values in which students receive an education. Therefore, student representation on the various committees is desirable. A teacher's role to motivate the students to fulfil physiological needs – physical settings of the classrooms etc., to give a sense of a safe environment, belonging along with student support systems will go a long way to help carry the curriculum forward. [32, 33]

The foundation course which will help to make the students work in collaboration - the sports activities, the discussions on the national programmes, communication skills, professionalism, ethics and clinical skills will be the starting

point in setting up the educational environment. That is why faculty attitude will help in making this happen. This will be coupled with the AETCOM and ECE modules. So, the onus lies with the 1 phase faculty and administration. Biochemistry faculty can play active roles in formulating the projects for the electives. Evaluating the educational environment with appropriate tools should be on the planning committee's agenda. [34]

Further, factors that work within the educational environment in medical colleges are a growing area of interest. The hidden curriculum is one such factor. Hidden curriculum refers to the unwritten, unofficial, and often unintended lessons, values, and perspectives that students learn in school.[35] While the "formal" curriculum consists of the courses, lessons, and learning activities students participate in, as well as the knowledge and skills educators intentionally teach to students, the hidden curriculum consists of the unspoken or implicit academic, social, and cultural messages that are communicated to students while they are in school. [35] Identification of the main components of a hidden curriculum could be of great help in maximizing its desirable values while decreasing its unfavourable results. [36, 37]

It is more than 2 years since the CBMC was rolled out in India. During this rollout and implementation of this, several challenges were encountered and the COVID-19 pandemic did not help matters. With the alignment of characteristics of CBME as per Frank et al[37], Holmboe et al[38, 39] and Van Melle et al[40], we propose some guiding principles to help support the implementation of CBME against all odds.

Learning experiences are effective learning process that could trigger the students to discover new things and learn from it. Skills which shall motivate the students to explore on new knowledge, trigger their curiosity and develop their critical thinking abilities are needed to be added to the Biochemistry curriculum. Perhaps, well conducted early clinical exposure sessions, involvement of Biochemistry in the family adoption programs and electives, where the practical aspects are discussed will improve expected learning outcomes.

## Conclusion

There is a need to emphasise higher cognitive domain competency together with the end of learning experience reflections to promote transformative learning and develop an in-depth knowledge of laboratory medicine principles for the IMG to be a practitioner of Evidence-Based Medicine. There is a variation in the ways that medical students learn the principles of biochemistry and relate them to medicine. To ensure that important principles are addressed it

is necessary to establish goals and objectives specifically related to Biochemistry laboratory practicals and experiment with optimal teaching and assessment methods. The aim is to sensitize the students at the pre-clinical phase about the optimal use of clinical laboratory diagnostics and therapeutics.[21].

Biochemistry educators need to help the students to connect knowledge of the biochemical reactions, cycles, regulations etc. to clinical medicine. Finally, they should be able to explain these principles to their colleagues and their patients and be ready to accommodate new scientific discoveries into their approach to patient care. [41] There is no doubt that the vertical integration of Biochemistry in Phases 2 and 3 as per the suggestions of the NMC shall help to consolidate the knowledge, skills and attitude towards the subject.

The optimal implementation of the CBME curriculum with a dedication that shall influence the growth of our students to become successful Indian Medical Graduates will be the turning point in the history of Indian CBME implementation.

## Suggestions for a Way Forward

The appraisal of the new NMC undergraduate curriculum in Biochemistry has shown that the curriculum makes an attempt to move toward integration of course content and defined the competencies in more measurable terms. However, it falls short on many fronts and needs to be evaluated with more precision. The following table summarizes steps to be taken to help make the Biochemistry curriculum more robust by identifying and teaching to defined learning outcomes, devising stepwise approaches to skill development and the use of programmatic assessment.

Table 3 attempts to summarize the changes that need to be introduced in the CBME Biochemistry curriculum.

There is no doubt that individual teachers shall impact educational change and it is these teachers that we need to inspire and encourage them to be the change agents [42]. As students enter medical school, the onus on the various stakeholders to mould the mindset of the students is tremendous. These stakeholders, including those involved in Biochemistry, shall all play a pivotal role in building the professional identity of the students [43].

We also need to recognize that CBME involves principles and approaches that are dynamic and there will be a constant necessity to evaluate, and evolve in such a way that all the stakeholders benefit from this entire exercise ---we cannot forget our learners as well as our patients.



**Table 3** Strategies to be introduced in CBME in Biochemistry

Themes	Suggestions for implementation of CBME Biochemistry
Learning outcomes	These should be defined in terms of knowledge, skills, attitude, professionalism and ethics.
Content	Content to be organized with appropriate horizontal and vertical integration. Bloom's taxonomy of raising the outcome from mere knowledge to being able to evaluate and create
Educational strategies	Educational strategies to be learner-centred. Emphasis on newer techniques such as jigsaw, flipped classroom, and peer learning.
Learning opportunities	Hands-on experience. Use ECE, SDL and the AETCOM to further this
Assessment	Formative assessment to be factored in with constructive feedback approaches. Programmatic assessment principles to be laid down.
Educational environment	All stakeholders to be involved in decision making. Hidden curriculum to be studied and ways of implementation to be worked out. Strong recommendation for an effective mentorship program. Pre-phase faculty shall play an important role.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s12291-022-01088-y>.

## Declarations

**Conflict of interest** There are no conflicts of interest.

**Competing Interests:** The authors have no competing interests to declare that are relevant to the content of this article.

## References

- National Medical Commission. Competency Based Under Graduate Curriculum. 2019. <https://www.nmc.org.in/information-desk-for-colleges/ug-curriculum/>. Accessed 01 Mar 2022.
- National Medicine Commission. Minimum Requirements for Annual M.B.B.S Admissions Regulation. 2020. <https://www.nmc.org.in/rules-regulations/minimum-requirements-for-annual-m-b-b-s-admissions-regulation2020/>. Accessed 15 Jan 2022.
- Medical Council of India. Competency based undergraduate curriculum for the Indian Medical Graduate. 2018. <https://www.nmc.org.in/wp-content/uploads/2020/01/UG-Curriculum-Vol-I.pdf>. Accessed 22 Feb 2022.
- Rajashree R, Chandrashekar DM. Competency-based medical education in India: A work in progress. *Indian J Physiol Pharmacol*. 2020;64:7–9. [https://doi.org/10.25259/IJPP\\_264\\_2020](https://doi.org/10.25259/IJPP_264_2020).
- Basheer A. Competency-based medical education in India: Are we ready? *J Curr Res Sci Med*. 2019;5:1–3. [https://doi.org/10.4103/jcrsm.jcrsm\\_18\\_19](https://doi.org/10.4103/jcrsm.jcrsm_18_19).
- Danielson JA. Key assumptions underlying a competency-based approach to Medical Sciences Education, and their applicability to veterinary medical education. *Front Vet Sci*. 2021;8:688457. <https://doi.org/10.3389/fvets.2021.688457>.
- Harden RM. Curriculum planning and development. In: Harden RM, Dent JA, editors. *A practical guide for Medical Teachers*. 4th ed. London: Churchill Livingstone; 2013.
- Wood EJ. How much biochemistry should a good doctor know? A biochemist's viewpoint. *Biochem Educ*. 1996;24:82–5. [https://doi.org/10.1016/0307-4412\(96\)88959-X](https://doi.org/10.1016/0307-4412(96)88959-X).
- Suneja S, Gangopadhyay S, Kaur C. Efforts to cope with CBME in COVID-19 era to teach biochemistry in medical college. *Biochem Mol Biol Educ*. 2020;48:670–4. <https://doi.org/10.1002/bmb.21469>.
- Afshar M, Han Z. Teaching and learning medical biochemistry: Perspectives from a student and an educator. *Med Sci Educ*. 2014;24:339–41. <https://doi.org/10.1007/s40670-014-0004-7>.
- Kanani D, Mishra A, Patel V, Patel A, Patel N. Learning medical biochemistry by combination of traditional & modern teaching methods: Students perceptions. *Int J Clin Biochem Res*. 2020;7:25–9. <https://doi.org/10.18231/ijcbr.2020.005>.
- Chaney KP, Hodgson JL. Using the five core components of competency-based medical education to support implementation of CBVE. *Front Vet Sci*. 2021;8:689356. <https://doi.org/10.3389/fvets.2021.689356>.
- Witharana C, Karunathilake I. A fascinating approach to learn biochemistry for medical student. 1st ed.: University of Colombo; 2021.
- Dongre AR, Chacko TV. A critical review of new competency-based curriculum for community medicine using various curricular review frameworks. *Indian J Public Health*. 2019;63:362–6. [https://doi.org/10.4103/ijph.IJPH\\_141\\_19](https://doi.org/10.4103/ijph.IJPH_141_19).
- Wilson ML. Educating medical students in laboratory medicine. *Am J Clin Pathol*. 2010;133:525–8. <https://doi.org/10.1309/AJCPQIA4FUGMVHT8>.
- Dandekar SP, Maksane SN, McKinley D. A survey validation and analysis of undergraduate medical biochemistry practical curriculum in Maharashtra, India. *Indian J Clin Biochem*. 2012;27:52–60. <https://doi.org/10.1007/s12291-011-0174-7>.
- Dandekar SP, Maksane SN, Mckinley DW. Design of medical biochemistry undergraduate laboratory based curriculum to address unmet needs. *SE Asian Jnl Med Educ*. 2017;11:43–53. <https://doi.org/10.4038/seajme.v11i1.8>.
- Khromova V, Gray TA. Learning needs in clinical biochemistry for doctors in foundation years. *Ann Clin Biochem*. 2008;45:33–8. <https://doi.org/10.1258/acb.2007.007122>.
- Dennick R. How much Biochemistry should a good doctor know? An educationalist's perspective. *Biochem Educ*. 1996;24:85–8. [https://doi.org/10.1016/0307-4412\(96\)00039-8](https://doi.org/10.1016/0307-4412(96)00039-8).
- Moreland BH. How much biochemistry should a good doctor know? *Biochem Educ*. 1996;24:79–. [https://doi.org/10.1016/0307-4412\(96\)00036-2](https://doi.org/10.1016/0307-4412(96)00036-2).
- Ananthakrishnan N. Competency based undergraduate curriculum for the Indian Medical Graduate, the new MCI curricular document: Positives and areas of concern. *J Basic Clin Appl Health Sci*. 2018;1:34–42. <https://doi.org/10.5005/jp-journals-10082-01149>.
- Smith BR, Agüero-Rosenfeld M, Anastasi J, Baron B, Berg A, Bock JL, et al. Educating medical students in laboratory medicine: A proposed curriculum. *Am J Clin Pathol*. 2010;133:533–42. <https://doi.org/10.1309/AJCPQCT94SFERLNI>.
- Walsh A, Koppula S, Antao V, Bethune C, Cameron S, Cavett T, et al. Preparing teachers for competency-based medical education: Fundamental teaching activities. *Med Teach*. 2018;40:80–5. <https://doi.org/10.1080/0142159X.2017.1394998>.
- Ansari S, Kumari S. Competency based medical education and its application in biochemistry. *Int J HealthCare Edu Med Inform*. 2019;6:7–9. <https://www.medicaljournalshouse.com/index.php/IntlJ-Healthcare-Education/article/view/247>. (Accessed 26 August 2022).
- Medical Council Of India. Electives for the Undergraduate Medical Education Training Program. 2020. <https://www.nmc.org.in/>

- [wp-content/uploads/2020/08/Electives-Module-20-05-2020.pdf](#). Accessed 24 Feb 2022.
26. Modi JN, Gupta P, Singh T. Competency-based medical education, entrustment and assessment. *Indian Pediatr.* 2015;52:413–20. <https://doi.org/10.1007/s13312-015-0647-5>.
  27. Medical Council of India. Assessment Module for the Undergraduate Medical Education Training Program. 2019. [https://www.nmc.org.in/wp-content/uploads/2020/08/Module\\_Competence\\_based\\_02.09.2019.pdf](https://www.nmc.org.in/wp-content/uploads/2020/08/Module_Competence_based_02.09.2019.pdf). Accessed 22 Feb 2022.
  28. Jagadeesan AR, Neelakanta RR. Online self-assessment tool in biochemistry – A medical student’s perception during COVID-19 pandemic. *J Educ Health Promot.* 2021;10:137. [https://doi.org/10.4103/jehp.jehp\\_792\\_20](https://doi.org/10.4103/jehp.jehp_792_20).
  29. McRae MP. Using clinical case studies to teach biochemistry in a doctoral program: A descriptive paper. *Creat Educ.* 2012;03:1173–6. <https://doi.org/10.4236/ce.2012.37174>.
  30. Anees S, Harakuni S, Kausar R. OSPE in Biochemistry –A step towards implementation of competency based undergraduate curriculum. *Int J Clin Biochem Res.* 2021;8:234–6. <https://doi.org/10.18231/j.ijcbr.2021.049>.
  31. Lockyer J, Carraccio C, Chan MK, Hart D, Smees S, Touchie C, et al. Core principles of assessment in competency-based medical education. *Med Teach.* 2017;39:609–16. <https://doi.org/10.1080/0142159X.2017.1315082>.
  32. Hutchinson L. Educational environment. *BMJ.* 2003;326:810–2. <https://doi.org/10.1136/bmj.326.7393.810>.
  33. Mohammad OA, Mahmoud SK, Abdulmohsen AZ. Learning environment in medical schools adopting different educational strategies. *Educational Research and Reviews.* 2010 Mar 31;5(3):126-9. <https://academicjournals.org/journal/ERR/article-full-text-pdf/6B3210D3967>. (Accessed 26 August 2022).
  34. Frank JR, Snell LS, Cate OT, Holmboe ES, Carraccio C, Swing SR, et al. Competency-based medical education: Theory to practice. *Med Teach.* 2010;32:638–45. <https://doi.org/10.3109/0142159X.2010.501190>.
  35. The Glossary of Education Reform. Hidden Curriculum Definition 2015. <https://www.edglossary.org/hidden-curriculum/>. Accessed 10 Apr 2022.
  36. Wachtler C, Troein M. A hidden curriculum: Mapping cultural competency in a medical programme. *Med Educ.* 2003;37:861–8. <https://doi.org/10.1046/j.1365-2923.2003.01624.x>.
  37. Mahood SC. Medical education: Beware the hidden curriculum. *Can Fam Physician.* 2011;57:983–5. <https://www.cfp.ca/content/57/9/983.short>
  38. Holmboe ES, Sherbino J, Englander R, Snell L, Frank JR, Collaborators ICBME. A call to action: The controversy of and rationale for competency-based medical education. *Med Teach.* 2017;39:574–81. <https://doi.org/10.1080/0142159X.2017.1315067>.
  39. Holmboe ES. The transformational path ahead: Competency-based medical education in family medicine. *Fam Med.* 2021;53:583–9. <https://doi.org/10.22454/FamMed.2021.296914>.
  40. Van Melle E, Frank JR, Holmboe ES, Dagnone D, Stockley D, Sherbino J, et al. A core components framework for evaluating implementation of competency-based medical education programs. *Acad Med.* 2019;94:1002–9. <https://doi.org/10.1097/ACM.0000000000002743>.
  41. Fulton TB, Ronner P, Lindsley JE. Medical biochemistry in the era of competencies: Is it time for the Krebs cycle to go? *Med Sci Educ.* 2012;22:29–32. <https://doi.org/10.1007/BF03341749>.
  42. Woodbury S, Gess-Newsome J. Overcoming the paradox of change without difference: A model of change in the arena of fundamental school reform. *Educ Policy.* 2002;16:763–82. <https://doi.org/10.1177/089590402237312>.
  43. Goldie J. The formation of professional identity in medical students: Considerations for educators. *Med Teach.* 2012;34:e641–8. <https://doi.org/10.3109/0142159X.2012.687476>.

**Publisher’s Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Springer Nature or its licensor holds exclusive rights to this article under a publishing agreement with the author(s) or other rightsholder(s); author self-archiving of the accepted manuscript version of this article is solely governed by the terms of such publishing agreement and applicable law.