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ORIGINAL ARTICLE

A Survey Validation and Analysis of Undergraduate Medical Biochemistry Practical Curriculum in Maharashtra, India

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Abstract In order to review the strengths and weaknesses of medical biochemistry practical curriculum for undergraduates and to generate ideas to improve it, a questionnaire was sent to 50 biochemistry faculty members selected (through simple random sampling method) from 42 medical colleges of Maharashtra, India. 39 responded to the questionnaire, representing a 78% response rate. The internal consistency of the questionnaire sections was found to be satisfactory (>0.7). The respondents did not agree that the ongoing curriculum was in alignment with learning outcomes (8%), that it encouraged active learning (28%), helped to apply knowledge to clinical situations (18%) and promoted critical thinking and problem solving skills (28%). There were a number of qualitative experiments that were rated 'irrelevant'. Qualitative and quantitative experiments related to recent advances were suggested to be introduced by the respondents. Checklists for the practicals and new curriculum objectives provided in the questionnaire were also approved. The results of the curriculum evaluation suggest a need for re-structuring of practical biochemistry curriculum and introduction of a modified curriculum with more clinical relevance.

Keywords Biochemistry · Validation · Undergraduate practical curriculum · Medical education

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Introduction

The idea of curriculum is hardly new but the way to understand and theorize it has altered over the years and there remains considerable dispute as to its meaning [1]. According to Kelly, Kerr defines curriculum as, 'All the learning which is planned and guided by the school, whether it is carried on in groups or individually, inside or outside the school' [2]. Schubert states that curriculum includes the contents of a subject, concepts and tasks to be acquired, planned activities, the desired learning outcomes and experiences, product of culture and an agenda to reform society [3]. Curricula of medical schools need to be regularly updated to reflect the latest advances in basic science and clinical care in order to improve the attitude of medical students towards the newer trends in medical education [4].

As a vital component of undergraduate medical education, the curriculum should empower medical students with a broad base of knowledge and practical skills to make them good clinicians. The success of today's medical students as future doctors depends on their practical skills which are developed during their undergraduate years. Compared to the traditional, course-centered approach to curriculum there is a need for more modern content and outcome-centered approach. In India, search for a need-based curriculum has been felt for a long time. In spite of this, the curriculum has not really changed. It is an often-repeated criticism that our medical colleges are producing graduates who are not well equipped to tackle the health care needs of the society [5].

Biochemistry is one of the basic medical science subjects introduced in the first year of medical school and is one of the foundation sciences for the medical curriculum. It forms the basis of all life sciences including the clinical sciences. Mahadevappa and Pawan Kumar [6] have stated that the advances in the field of medical science are simply overwhelming and biochemistry occupies the central place in this endeavor. The profession of clinical biochemistry is rapidly merging with other disciplines in laboratory medicine. In the background of this rapid growth it has become essential that biochemistry is taught in the correct perspective to the students in medicine. In reality, however, in Indian medical schools, biochemistry is taught without concerning factual knowledge of clinical sciences [6]. Clinical biochemistry learning assumes great importance in the betterment of the role of medical students as the foundation doctors. In a study conducted by Victoria Khromova, it was found that the junior doctors requested for most of the biochemical tests, many of which were inappropriate. Also the results of the tests are often misinterpreted by them due to their limited preparedness in clinical biochemistry [7]. The practical biochemistry curriculum plays a very important role in inculcating the basics of clinical medicine in the students. The main objective of the practical curriculum is to justify the selection of appropriate biochemical investigations for common clinical cases and explain the fundamental principles underlying such investigative techniques. Hence the curriculum must be designed in such a way that it can fulfill the above mentioned objectives of biochemistry [8]. The curriculum should be structured to balance learning opportunities and to integrate the learning of basic and clinical sciences, enabling students to link theory and practice [9]. Through various observations, informal discussions and formal meetings, opinions have emerged that the current practical curriculum fails to evaluate whether specified learning objectives are met. Further, there is a need to create an appropriate alignment with the teaching learning methods and assessment. The biochemistry practical curriculum of the Maharashtra University of Health Sciences (MUHS) has been drafted in accordance to the Medical Council of India regulations and is more or less similar in most of the colleges all over the country (www.muhsnashik.com).

Surapaneni [8] concluded that innovative curriculum with case based learning coincided with improved academic performance. This study reflects that practical learning in biochemistry is very important in medical education. Mishra [10], found that there is an agreement among the doctors and medical students that the content, methods of teaching, and curriculum organization of training in clinical biochemistry need to be modified.

The aim of this study was to collect and analyze opinions of biochemistry faculty members on the efficacy of current biochemistry practical curriculum put forth by the University, in achieving the specified learning objectives, to understand the strengths and weaknesses and to improve it.

Methods

To determine the perception of faculty about the strengths and weaknesses of the practical curriculum, a questionnaire was prepared. A list of 150 biochemistry faculty members including professors, associate professor and lecturer from 42 medical colleges of Maharashtra was prepared and numbering was done. From this list, 50 members were selected through simple random sampling method. 50 selected faculty members were provided questionnaires. (via mail or by hand). In an accompanying letter, the syllabus of MUHS for biochemistry practical skills and purpose of the study were provided. Respondents were invited to state their opinions on each individual theme, on the ways for strengthening the practical curriculum. Before formulating the questionnaire, faculty, interns and medical students were interviewed. On the basis of their responses the questionnaire was formed. The questionnaire was organized based on the current curriculum and asked faculty members for their opinions about the (1) qualities of practical curriculum; (2) biochemical parameters included in the qualitative, quantitative experiments and spots; (3) marks allotment for qualitative and quantitative experiments; (4) alignment of objectives, teaching/learning methods and assessments (qualitative and quantitative experiments); (5) marks allotment for urine report, organic constituents of urine and inorganic constituents of urine. When respondents were asked questions about the qualities of the biochemistry practical curriculum, a four-point agreement scale was used (1-strongly agree, 2-agree, 3-disagree, 4-strongly disagree). When asked about more specific parameters included in the curriculum a four-point relevance scale was used (1-not relevant, 2-moderately relevant, 3-relevant and 4-extremely relevant). For alignment of objectives and teaching methods with assessments, respondents were asked whether they agreed or disagreed. In each section of the questionnaire, space was also provided for additional comments. International Federation of Clinical Chemistry (IFCC) recommended topics related to clinical biochemistry were also provided in the questionnaire for their ranking according to their importance.

Data Analysis

Quantitative questionnaire data were analyzed with SPSS software, version 17. Cronbach's alpha was calculated to measure internal consistency of items in the questionnaire [11, 12]. A minimum percentage of 75% was set to indicate agreement on any particular item of all themes [13]. Ratings of 1 and 2 on the four-point relevance scale were combined to represent "relevant" while ratings of 3 and 4 were combined to represent "irrelevant". Agreement ratings were combined in a similar fashion; ratings of 1 and 2 indicated agreement. Respondents' suggestions were analyzed by coding comparable comments expressed by two or more respondents as key points. The key points were organized into categories to develop the topics [14]. Open ended comments were coded with attention to generated topics. The suggestions were also compiled and used to review and restructure the practical curriculum. If there was less than 75% agreement/relevance for any curricular element, data were reviewed to determine whether respondents made suggestions for improvement in response to the open-ended questions.

Results

Cronbach's alpha was calculated for the themes, to judge the internal consistency of the questionnaire. The internal consistency was found to be satisfactory. Cronbach's alpha for 9 items on "qualities of practical curriculum" was 0.70; for 31 items on "biochemical parameters in quantitative and qualitative experiments and spots" was 0.87; for 12 items of "checklist with marks allotment for quantitative and qualitative experiments" was 0.75; for 10 items on "objectives for quantitative and qualitative experiments" was 0.72, for 27 items on "checklists for urine report and organic and inorganic constituents of urine was 0.73 and for all 2 scale items the Cronbach's alpha was 0.76.

Out of the total 50 questionnaires sent to the faculty, 39 responded (78% response rate). All the data from the respondents was assessed to find out the relevance and degree of agreement of the objectives and parameters in the questionnaire. The following six qualities were agreed upon by less than 75% of the respondents from the theme "qualities of practical curriculum": (1) the curriculum is in alignment with the learning outcomes, teaching–learning methods and assessments (8%); (2) the practical curriculum helps to apply knowledge to clinical situations (18%); (3) in general, the practical curriculum encourages active learning (28%); (4) the practical curriculum promotes critical thinking and problem solving (28%); (5) the laboratory exercises with respect to quantitative experiment encourage solving skills (25%); (6) the laboratory exercises with respect to spot learning encourages problem solving skills (39%) (Table 1).

Nine curricular elements were considered relevant by less than 75% of the pooled respondents: creatinine in urine (21%); test for monosaccharides (10%); tests for disaccharides (5%); colour reactions of proteins (5%); precipitation reactions of proteins (5%); normal organic constituents of urine (10%); identification of slide under microscope (23%); use of reagent (15%); and specimens of calculi (57%). All of the surveyed elements of quantitative experiments were scored as relevant by more than 75% of the pooled respondents (Table 2).

All items regarding mark allotment qualitative experiments were agreed upon by more than 75% of the pooled respondents. When asked about mark allotment for quantitative experiments, less than 75% of the faculty surveyed agreed that marks currently allotted for 'causes for the disease conditions are enumerated' (69%) and 'the work desk was left in a clean state with the experimental tubes appropriately labeled (46%)' were adequate (Table 3).

Table 1 Pooled respondents' opinions on the statements about undergraduate practical curriculum (scored on a four point Likert scale)

S no.	Statements about ongoing practical curriculum	Strongly agree (%)	Agree (%)	Disagree (%)	Strongly disagree (%)	Agreement scale values 1 and 2 (%)
1	The curriculum is in alignment with the learning outcomes, teaching–learning methods and assessments	–	8	31	61	8
2	The practical curriculum helps to apply knowledge to clinical situations	–	18	36	46	18
3	In general, the practical curriculum encourages active learning	–	28	8	64	28
4	The practical curriculum promotes critical thinking and problem solving	–	28	18	54	28
5	The laboratory exercises with respect to quantitative experiment encourage solving skills	15	10	36	39	25
6	The laboratory exercises with respect to spot learning	–	39	33	28	39
7	Problem-solving skills can be increased by using different spots	41	38	21	–	79
8	There is consistency in the scoring of students between the examiners in both University and College examinations	28	62	10	–	90
9	Students are aware of the marking scheme at University level	41.0	59.0	–	–	100

Table 2 Pooled respondents' opinions on the statements about specific parameters included in the practical curriculum (scored on a four point Likert scale)

Sr. no.	Parameters	Not relevant (%)	Moderately relevant (%)	Relevant (%)	Extremely relevant (%)	Relevant scale values 3 and 4 (%)
Group A: Quantitative experiments (maximum 20 marks)						
1	Blood sugar	–	–	10	90	100
2	Blood urea	–	3	20	77	97
3	Serum total protein	–	3	23	74	97
4	Albumin	–	3	23	74	97
5	A/G ratio	–	–	18	82	100
6	Alanine amino transaminase (SGPT)	–	–	28	72	100
7	Aspartate amino transaminase (SGOT)	–	–	15	85	100
8	Alkaline phosphatase	–	8	13	79	92
9	Serum amylase	8	2	3	87	90
10	Serum total bilirubin	–	5	21	74	95
11	Serum uric acid	5	5	5	85	90
12	Serum calcium	–	10	8	82	90
13	CSF sugar	–	13	8	79	87
Group B: Qualitative experiments (maximum 15 marks)						
1	Creatinine in urine	56	23	18	3	21
2	Serum cholesterol	5	8	33	54	87
3	Serum phosphorus	–	13	51	36	87
4	CSF protein	5	10	36	49	85
5	Tests for monosaccharides (Benedict, Barfoed, Seliwanoff, Nylander, Rapid furfural)	64	26	2	8	10
6	Tests for disaccharides	85	10	3	2	5
7	Colour reactions of proteins	82	13	–	5	5
8	Precipitation reactions of proteins	72	23	–	5	5
9	Normal organic constituents of urine	46	44	5	5	10
10	Abnormal constituents of urine	–	–	13	87	100
Group C: Spots (maximum 5 marks)						
1	Identification of slide under microscope,	13	64	13	10	23
2	Use of reagent.	44	41	5	10	15
3	Significance of test	–	3	74	23	97
4	Use of instrument/appliances.	3	15	69	13	82
5	Identification of Hb- derivative.	3	5	28	64	92
6	Identification of GTT	–	–	23	77	100
7	Electrophoretogram and chromatogram	–	–	13	87	100
8	Specimen of calculi	10	33	31	26	57

One objective was agreed upon by less than 75% of the respondents from the theme "Objectives, teaching–learning methods and assessments (quantitative experiments)":

(1) Students should be able to achieve a high degree of practical competency in routine analysis (54%). All points in the theme "objectives for qualitative experiments" were agreed by all the respondents (Table 4). Checklists for urine report, organic and inorganic constituents of urine were agreed as adequate by more than 75% of the pooled respondents (Table 5).

Qualitative and quantitative experiments related to recent advances were also suggested by 36 respondents (92%) which are as follows:- radioimmunoassay (RIA), enzyme linked immunosorbant assay (ELISA), polymerase

Table 3 Pooled respondents' opinions on the checklists with marks allotment and for quantitative and qualitative experiments on two point Likert scale

Sr. no.	Quantitative experiments	Marks allotted	Agree (%)	Disagree (%)
1	The principle of the experiment is stated	2	90	10
2	Is the role of the various reagents used adequately described?	2	87	13
3	Was the experiment performed in a logical manner?	3	85	15
4	Is the method of calculation of results clear?	2	82	18
5	Are the result interpreted properly?	3	92	8
6	Are the causes for the disease conditions enumerated?	2	69	31
7	Was the work desk in a clean state with the experimental tubes appropriately labeled?	2	46	54
8	Was the experiment, glassware handled with confidence?	1	80	20
9	On the basis of random questions, did the student exhibit that he/she understood the test?	3	92	8
Total		20		
Qualitative experiments				
1	The qualitative test was performed as per protocol	1	100	–
2	The application of the test was explained appropriately	2	97	3
3	The test was interpreted to satisfaction	2	100	–
Total		5 × 3 = 15		

This scheme of qualitative experiments can be used for three tests. So the total number of marks allotted is 15

Table 4 Pooled respondents' opinions on the objectives of quantitative and qualitative experiments on two point Likert scale

Sr. no.	Objective for quantitative experiments	Teaching learning methods	Assessment	Agree (%)	Disagree (%)
1	The students shall be able to state the principles of the experiments	Tutorial	Marking	92	8
2	The students should incorporate basic theory and laboratory skills	Demonstration	Observation	97	3
3	Students should be able to achieve a high degree of practical competency in routine analysis.	Small group sessions	Direct observation	54	46
4	The students shall be able to interpret the results of commonly used investigations effectively	Small group	Checklist	90	10
5	Help develop critical thinking skills	Self instructions, preparation of cases in a group	Tutor's opinion, Observation	87	13
6	Student should have a basic understanding of the clinical application and limitations	Discussion	Marking	97	3
7	Students shall be able to use laboratory equipments with confidence	Demonstration/Hands on training	OSPE	80	20
Objective for Qualitative experiments					
1	Student shall be able to understand the principles of the test	Demonstration	Marking	95	5
2	Student shall be able to explain the use of each reagent	Tutorial	Checklist	95	5
3	Student shall be able to apply the principles taught to interpret the results obtained in urine report	Tutorial, demonstration and Practical	Checklist	97	3

chain reaction (PCR), lipids and lipoprotein profile, thyroid profile, hormone assay, c-reactive protein, troponins, creatine kinase, prostate specific antigen, electrolyte (Na^+, K^+, Mg^{++}, Cl^-) analysis, protein purification, gene sequencing, DNA extraction, gene cloning, recombinant DNA technology, antioxidant enzymes.

Final list of ranking of the topics (according to their importance) to teach in order to enhance clinical applications was also prepared using ratings provided by pooled respondents (Table 6).

On the query of including blood collection principles at this stage of curriculum, 37 out of 39 (95%) respondents replied and 34 respondents (87%) agreed with this suggestion (>75%). 37 out of 39 respondents (95%) suggested topics for case studies which are as follows:- enzymology, kidney function tests, liver function tests, hormones, purine

Table 5 Pooled respondents' opinions on the checklists with marks allotment for urine report and organic and inorganic constituent of urine on two point Likert scale

Particulars (urine report)	Marks allotted	Agree (%)	Disagree (%)
Physical characteristics (writing + performing)			
Specific gravity	1	100	–
Rest of the parameters such as colour, odour, etc.	1	95	5
Chemical constituents (writing + performing)			
Proteins, glucose	1	100	–
Blood	1	95	5
Bile salts and pigments	1	97	3
Ketone bodies	1	97	3
	1	100	–
Clinical interpretation of the positive constituents (generally we keep two positive constituents)	2	90	10
Viva voce	5	87	13
Report presentation format	1	92	8
Total	15		
Particulars (organic constituents)			
Physical characteristics (writing + performing)			
Specific gravity	1	97	3
Rest of the parameters such as colour, odour, etc.	1	97	3
Chemical constituents (writing + performing)			
Specific urease test	1	100	–
Hypobromite test	1	97	3
Benedicts uric acid reagent test	1	95	5
Schiff's test	1	97	3
Jaffe's test	1	95	5
Test for hippuric acid	1	92	8
Test for ethereal sulphates	2	95	5
Viva voce	5	92	8
Total	15		
Particulars (inorganic constituents)			
Physical characteristics (writing + performing)			
Specific gravity	1	97	3
Rest of the parameters such as colour, odour, etc.	1	97	3
Chemical constituents (writing + performing)			
Test for inorganic sulphates	1	95	5
Test for chlorides	1	92	8
Test for Calcium and Phosphates	4	95	5
Test for ammonia	2	82	18
Viva voce	5	97	3
Total	15		

metabolism, mineral metabolism, vitamins, carbohydrate metabolism, fatty acid metabolism, prions, immunology, inborn errors of metabolism, iron and haemoglobin metabolism, prostaglandins, cancer, diet and nutrition, acid–base balance, genetic diseases and toxicology.

In order to improve current curriculum, respondents' suggestions on various aspects were noted and presented in a table form. Themes that emerged from the suggestions and recommendations by 31 out of 39 respondents (80%) for strengthening the biochemistry practical curriculum are documented in Table 7.

Discussion

The current practical curriculum lacks critical thinking and problem solving qualities which is one of the important objectives based on the results of the questionnaire.

Table 6 Ranking of clinical biochemistry topics (suggested by IFCC) according to their clinical importance

Rank	Topic
1	Clinical enzymology
2	Liver function
3	Lipid and lipoproteins
4	Hereditary disorders
5	Purine metabolism
6	Renal function
7	Plasma proteins
8	Carbohydrate metabolism
9	Heme and porphyrins
10	Acid base balance
11	Water and ionic balance
12	Endocrine function
13	Nutrition
14	Calcium phosphate and magnesium metabolism
15	Gastro intestinal function
16	Toxicology
17	Clinical chemistry of pregnancy

Formulation of case histories in practical curriculum is the best way to develop critical analytical skills in medical students. In our study, it was a general opinion of faculty members that students should learn about the abnormalities in clinical biochemistry. Short case histories followed by formulation of relevant investigations, interpretations of laboratory results, diagnosis of disease and various metabolisms involved were suggested as additions to the practical biochemistry curriculum. Such biochemistry practical modules will encourage the students to be prepared for patient encounters.

There should be an explicit connection between observed clinical problems and the knowledge base that the medical students are acquiring during undergraduate teaching [15]. In the present study it was noted that qualitative and quantitative experiments included in the current curriculum are not in context with the rapidly developing modern diagnostic methods. Instead of these parameters some advanced and appropriate biochemical parameters of diagnostic importance should be added. Diagnosis of diseases through electrophoretic pattern, photographs of some disease conditions correlating with the biochemical tests, laboratory instruments to be used as spots were suggested to be included by the respondents.

Interpretation of laboratory results is important for clinical diagnosis. It is a fact that the pathways are complex and students have little training in diagnostic services and laboratory medicine [16]. Most of them have little understanding of what tests to order and how they should be interpreted [17].

Furthermore, the students are taught practicals which they will never apply or practice in future. There is no synchronization with the modern methods. There is a tremendous amount of research and new knowledge in biochemistry and its application in clinical practices. The students however are not able to interpret the results of modern parameters used in the diagnosis of the diseases even after becoming doctors because the current curriculum does not include new and advanced biomarkers. Also, there is no awareness of how the modern parameters can be used in the diagnostic laboratories, and how to interpret them in relation with the clinical cases. It was concluded that in the absence of this, the medical students will not be competent in requesting and interpreting investigations during their clinical practices [17]. In IFCC guidelines for teaching clinical chemistry to undergraduate medical

Table 7 Themes developed by respondents' opinions on strengthening the practical curriculum

S.R. no.	Themes	Key points
1	To arrange clinically oriented practical and lectures.	To include new biomarkers, to arrange practical oriented lectures, to make learning interesting by adding photographs, electrophoretic patterns etc.
2	Experience of working in biochemistry laboratory.	Waste management, students should learn sample collection and storage. Handling of diagnostic reagents, reagent preparation and storage, quality control.
3	Knowledge of modern laboratory instruments and equipment.	To expose them to work with and handle modern equipment such as electrolyte analyses and auto analyzers. Addition of new techniques such as HPLC, chemiluminescence, blood gas analysis, RIA, ELISA and PCR.
4	More emphasis should be given to modern method of diagnosis but classical method should also be taught.	Modern diagnostic methods which are used in the laboratories should be included.
5	To enhance the knowledge of students through practical experiences to make them good clinicians.	Students should get experience of correlating the report with the clinical condition of patient.
6	Bioinformatics in relation to biochemistry should also be added in biochemistry practical curriculum.	Bioinformatics is an important aspect about which students can be sensitized.

students, it is mentioned that the undergraduate must acquire an ability to request appropriate clinical chemistry tests and must develop some expertise in interpretation of results. This IFFC document is intended to serve as guidelines for the preparation and delivery of a course in clinical chemistry for medical students to enable them to make proper use of the laboratory for the benefit of their future patients [18]. The IFFC has also suggested certain clinically important biochemical topics to be used in the curriculum. These topics were included in the questionnaire and they were given a ranking by the respondents according to their clinical importance. These important clinically ranked topics can be incorporated into clinical cases and used in the practical curriculum as suggested by the respondents. (Table 6) It was a general opinion of the respondents in the study that modern instruments commonly in use in biochemistry laboratories, their functioning, applications and principle of working should be added to the curriculum.

There are certain aspects currently taught in the curriculum which have no clinical relevance and are outdated. One example of experiments with no clinical relevance is biochemical tests for monosaccharides and disaccharides. Our respondents were in strong disagreement regarding inclusion of such tests in the curriculum. Instead of such tests, the biochemical tests routinely used in clinical practice should be included. Also, the current curriculum places emphasis on the technical details and proficiency of the students in performing the quantitative tests. The respondents were of the opinion that instead of this, the students should be able to state the principles of the tests and to interpret biochemical laboratory values.

Further currently, there are no criteria for allotment of marks. There should be a pattern of mark distribution in qualitative and quantitative experiments. A checklist suggesting a systematic approach to awarding marks was included in the questionnaire. This was approved by most of the faculty members.

A study focused on the technical details and other theoretical aspects of biochemistry teaching found that very little training in the diagnostic services was given to the students [19]. Re-creating a curriculum is intimately linked to the needs of learners along with society needs which periodically require re-examination [20]. It is only through a thorough and systemic approach to planning and evaluation that this is possible [21]. To facilitate the needs of tomorrow's doctors and patients' benefit, all these suggestions on different aspects were considered for updating the biochemistry practical curriculum. There are some limitations to this study. Firstly, the questionnaire was sent to only 50 out of approximately 150 faculty members. Secondly, although the traditional curriculum is based on a national perspective, the faculty chosen was from just one university. So, the survey offers a snap shot of the views of the faculty. Therefore, it would be valuable in future to involve more faculty members. Alternatively, a revised curriculum can be evolved and then sent to more faculties for opinion. We have started in a small way, but there is still a long path to be traversed.

Conclusion

This study provides a need assessment for a change in biochemistry practical curriculum of one Indian state—Maharashtra but also highlights a serious issue affecting biochemistry practical education in all Indian medical schools. The questionnaire developed for this study can now be used to improve the present biochemistry practical curriculum at national level. It can be used for opinion from faculty from all over India because the premise on which the questionnaire is based is on the national directives (Medical Council of India). There is a dire need for re-structuring of current undergraduate practical biochemistry curriculum. Old and outdated curriculum should be replaced with innovative curriculum with more conceptual and global views to improve the attitude of Indian medical students towards the modern trends in biochemistry.

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