AN INTEGRATED PROBLEM-BASED CURRICULUM FOR BIOCHEMISTRY TEACHING IN MEDICAL SCIENCES

Dinesh Puri

Reader, Department of Biochemistry
University College of Medical Sciences, Delhi-110095,
India

One of the principal objectives of medical education is to produce medical personnel having sound clinical competence and community orientation with proficient communication skills. A combination of these qualities is necessary to solve the formidable health problems (1). However, there is a general dissatisfaction with the prevailing medical practices and one of the main reasons for such dissatisfaction has been identified as the present day medical curricula. This puts a tremendous responsibility on the institutions providing medical education for bringing about the required innovations in the existing systems to meet the defined needs of the societies in their areas of operation (2, 3). Medical Council of India has stressed upon community oriented and need-based curriculum, which should stimulate student's interest and inculcate drive to learn more mainly through an active self-directed approach rather than through didactic teaching. Teachers assume new role as consultants or resource persons, who would concentrate on facilitating the process of active learning rather than overloading students with excessive details through a series of elaborate lectures and voluminous books. Such student-centered approach is expected to make learning a pleasure and subsequent use of knowledge base in an effective manner in clinical practice, so as to be more useful to the community. Except for a few of over 1350 medical schools all over the world (over 140 in India), majority follows discipline-based, teacher-centered, examination-oriented, standard programs where learners are presented with a series of disciplines or building blocks in isolation. Such models are under criticism for placing too much emphasis on memorization of facts and figures and for overloading the students with excessive details, more so in recent times that have seen unprecedented expanding knowledge base and accelerated information input. An

avalanche of information has been created in biochemistry, as in other basic sciences, which has made it futile and impossible to provide whole content of knowledge to students in the medical curriculum. It has therefore become necessary to review and carefully re-examine what ideas, facts and attitudes are required by undergraduate students in the field of medical sciences. Keeping these in view, an innovative curriculum based on SPICES model (4), and a unique teaching methodology, were developed in BP Koirala University of Health Sciences (BPKUHS), a residential university in Eastern Nepal (with a 500 bedded hospital attached).

An innovative curriculum: The BPKUHS is the largest Nepal-India cooperation health project in Nepal so far, and is envisioned to be a nucleus of academic excellence. The curriculum followed is the ultimate outcome of cooperative efforts of eminent medical educationalists from India, Nepal and WHO consultants, who carefully evaluated the existing medical systems and perceptions of health professionals before translating their vision into action plan at the International Conference of Medical Education held in Dharan (5). The curriculum stresses upon *small-group approach*, to enable the students to learn concepts of small-group dynamics and teamwork; and *problem-based approach*, to enable them to find answers to biomedical problems through self-directed learning and use of appropriate resource materials. Thoroughly integrated and to the extent possible problem-based, the curriculum incorporates organ-system pattern and encompasses all parameters outlined in the SPICES model (6). Though markedly different from the conventional model (Table 1), it does not fully dissociate from the latter; rather, it builds on strength of old and adds new dimensions to it.

Salient features: The curriculum has been divided into two phases: Phase I of two years, and Phase II spanning over two and half years. During Phase I, the emphasis is on basic medical sciences (BMS), including biochemistry; while in Phase II stress is

Address for Correspondence:

Dr. Dinesh Puri
B-163, Yojna Vihar
Delhi-110095, India
E mail: dbmi@ucms.ernet.in Fax: 0112290495

on clinical sciences along with community medicine. A high degree of interaction between basic medical sciences and clinical sciences throughout the course is the hallmark of this curriculum (7). Interaction is aimed to be achieved at both horizontal and vertical levels, with emphasis on early patient contact and community medicine. A conceptual framework of the MBBS program is depicted in Fig. 1. In this innovative curriculum biochemistry has been kept as a separate subject, with importance at par with the other basic medical sciences subjects, viz, Anatomy, Physiology, Pathology, Pharmacology and Microbiology, both in terms of teaching hours and marks allotted in examinations. Following orientation program for about a week, basic fundamental concepts of various BMS are taught during the Unit zero. These concepts are strengthened by a large number of unconventional learning exercises that promote students participation. Distinction between various subjects gets blurred with integrative approach that is practiced during the subsequent units when organ systems are dealt with. When a particular organ system is taken up, for example endocrinology during unit III, various subjects deal with the pertinent aspects of this system from their viewpoint. Biochemistry would aim to teach mechanism of hormone action, second messengers, hormone receptors etc, Physiology will aim at biological effects of individual hormones, Pathology will concentrate on endocrinal disorders, while Pharmacology will highlight treatment strategies of the same. In this way, efforts of various disciplines are coordinated so as to achieve the ultimate goal of providing thorough understanding. Thus the organ system represents an integrated approach to learning medicine, which has been reported to be an effective means of imparting medical education and a viable alternative to the traditional curriculum based on disciplines (7, 8). To further emphasize utility of integrated approach, and also to recapitulate and reinforce the basic concepts, a problem based multi-disciplinary learning exercise of one week duration is organized at the end of each organ system.

Innovative learning tools designed to put into practice the above curriculum strategy are discussed below.

Learning tools: These tools encourage the student to acquire facts through active experiential and self-directed approach, relegating into background the learning through rote memory.

SIS (Structured Interactive Sessions): These are theory sessions which provide the core-content subject information. They differ from the conventional didactic lectures in being structured and for placing greater emphasis on student-teacher interaction. The must know areas are stressed upon and the teacher outlines objectives, scope and content of the lecture. In contrast to one-way communication in didactic teaching, the students are encouraged to actively participate in the learning process through greater interaction. The teacher also takes a new role as a consultant (resource person) or facilitator (tutor) rather than act as a conventional teacher who would take every possible opportunity to tell all he/she knows to the students. Such alteration of roles allows students to generate their own ideas through discussions, which is an important factor for facilitating greater achievement and better retention of knowledge.

SIS have been found particularly useful in preclinical subjects, including biochemistry, as they provide a chance to frequently recall and discuss the fundamental concepts and correlate them with patho-physiology of organ systems. Frequent recall and application of biochemical concepts in clinical context not only strengthens their grasp over basics, but also serves to bridge clinical realities with basic medical sciences from an early stage.

UNCLE (Unconventional learning exercises): These are cooperative participatory exercises, which aim to strengthen and reinforce the subject core-content (learnt earlier in SIS) through quiz sessions, small group discussions, student debates and role-plays. Such exercises collectively called UNCLE – the name originated in BPKUHS- were found to serve as important instruments of learning in an integrative curriculum. In contrast to conventional discipline based teaching, the UNCLE sessions seem to shift emphasis to the process of learning rather than the content and the product. They provide a student centered environment in which the learners assume the responsibility of discussing various academic issues, rather than sitting back and waiting to be told the correct answer, as is invariably the case with conventional lectures and tutorials. The UNCLE sessions also enhance intrinsic motivation, promote self-directed learning and provide context for developing ability to work in team with a common goal. A major advantage emerging out of this approach has been improvement in presentation skill of students. They get habituated to appreciate

receiving and in turn to offering constructive criticism. Beneficial effects of this ability, developed in early stages, have been found to be sustained and lasting.

Labex: These are *laboratory exercises* aimed to develop skills for performance and interpretation of biochemical tests. These exercises are also conducted in organ system fashion and given clinical orientation to the extent possible. Students are provided with brief case history of the patient together with the blood/urine samples for the estimation of the biochemical parameter(s). Following the estimation of the biochemical parameter(s), they are asked to interpret the results and correlate them with clinical features. The exercises are designed in organ system fashion; for example during unit II when GIT and hepato-biliary systems are covered (Fig.1), the related practical exercises, such as estimation of serum bilirubin, transaminases, alkaline phosphatase, and serum proteins are carried out; and the renal parameters such as creatinine and urea clearance are covered during Unit IV with genitourinary system.

Problem based learning: The self-directed organ based teaching is supplemented by problem-based exercises, which have been recognized as effective integrated approach to learning medicine through real and simulated health problems. The problem base orientation was given to this new curriculum in view of reports that medical knowledge can not be considered in isolation from the process of problem solving and that student led discussion groups are superior in learning complex material in term of memory retention (8, 9). Development of student-initiated enquiry strategies was therefore given precedence in BPKUHS over the student-centered achievements of teacher made packages.

A problem-based exercise has two essential components: tutor-assisted sessions and resource-sessions. Each exercise is organized at the end of an organ system and is structured around a health problem related to that system. Thus during Phase I, comprising of eleven organ systems (Fig.1), a total of eleven problem-based exercises, each of one week duration are organized. Biochemistry plays an important role in most of these exercises, especially where the health problem has a strong biochemical basis. Diabetes mellitus or thyrotoxicosis (during unit III, endocrinology), lactic acidosis (unit IV, acid-base chemistry), viral hepatitis (unit II, gastrointestinal tract and liver), coronary artery disease (unit I, cardiovascular system), brittle

bone syndrome (unit V, skeleto-muscular system), porphyrias (unit V, haematology) or Parkinson's disease (unit VI, central nervous system) are some of the examples. The problem-based learning sessions are conducted in small groups during this one-week period, each group being assisted by a tutor. During the first tutor-assisted session, each student group is given initial part of the patient's case-sheet (termed a trigger), and the students are encouraged to study it carefully so as to identify a number of issues (knowledge and skills) that need to be acquired for solving the problem. These are termed *learning needs or learning objectives*. The assisting tutor also provides references of the resource materials –books or journals – where the student may find the required information in library. For each problem, teachers from different specialties are chosen as resource persons who would play important role in solving student's queries and in plugging lacunae in their knowledge. Theory classes called resource sessions are held for the purpose, but the students are free to contact a resource person any time during working hours. Evidently, a student-centered environment prevails throughout this process, with a lot of emphasis on self-study, which provides intrinsic motivation for meaningful learning and a context for developing enquiry and problem-solving skills. Learning, as it progresses, constantly circles back to build upon previous knowledge, so the student gets an opportunity to use whatever knowledge he has acquired and add to it the new knowledge in the process.

During the subsequent tutor assisted sessions, conducted on alternate days, the students are encouraged to discuss the facts and information which they learnt themselves in the self-study sessions or from the resource persons. The tutor plays a rather passive role during these discussions, but ensures that the discussions are relevant and meaningful. He also provides the student the next trigger(s) or further material related to the case under study, e.g., physical examination findings, laboratory reports, results of radiological or other investigations, opinion of specialist(s) if any, tentative diagnosis etc. Fresh learning objectives are laid and students proceed to search further information. At the end of the week, a student seminar attended by the faculty is organized where one student from each group is chosen to present a given aspect of the health problem. These sessions are meant to be highly interactive. At the end, student feedback is obtained through a structured performa.

Hospital postings: The wide knowledge base attained because of exposure to clinical sciences from an early stage is strengthened by early patient contact through hospital postings (Fig.1), where some simple cases related to the organ system under study are shown and discussed. Assisted by a clinician-tutor for each small group, the students are demonstrated importance of thorough history taking, shown relevant clinical-signs, and stressed upon importance of correlating basic medical facts learnt in class-room with the clinical reality.

Learning experiences in biochemistry: Teaching in biochemistry starts at the beginning of Phase I of MBBS program and continues till the end of this phase. Throughout this period, teaching through lectures is restricted to the extent possible and other unconventional exercises are encouraged. The theoretical concepts learnt through SIS arranged in organ system fashion are continually reinforced by unconventional learning carried mainly by small group discussions and problem based sessions, as discussed. Student's participation is the focal point in these activities. As per our experience, the student led discussion groups are gradually found to adopt deep approach to learning where emphasis shifts to understand the learning material, critically examine arguments, and relate them to previous knowledge; this is in sharp contrast to surface approach to learning where they simply resort to rote memorization of facts, in isolation, perhaps without understanding at times.

Independent study is encouraged from the beginning; a large part of student's time being spent in self-study, pursuing learning issues arising from unconventional learning exercise sessions or self-generated. Interaction with faculty members is also encouraged, who act as important resources for learning. In essence, the focus is on what the learner is doing rather than what the teacher does. In this process, the teacher functions primarily as a procedural guide and only secondarily as a resource for content information. The Chinese proverb "You give a man a fish, you feed him for a day – you teach him to fish, you feed him for life" gives a philosophical basis for the self-directed, life-long learning.

At the end of every organ system, students are encouraged to evaluate the teaching activities and suggest improvements by filling up a structured questionnaire. This serves as a useful feedback to

know adequacy of teaching. Every attempt is made to follow constructive criticism with some improvement(s) in the teaching methodology to the extent possible.

Assessment: The assessment tools in BPKUHS aim to test not only the intellectual quality and academic achievement, but also personal qualities of the students. The weightage given to biochemistry in the examinations conducted at the end of the first year (second semester) and the second year (fourth semester) of Phase I is quite at par with the other subjects of basic medical sciences. The students go through both formative and summative evaluations.

Internal Assessment: Students are evaluated at the end of each semester through an integrated examination that includes all major subjects of BMS. Separate examinations for different subjects are not held; rather examinations are based on organ systems with contributions coming from different disciplines. Students are also assessed during the unconventional learning exercises that are held throughout their curriculum for the following:

- Interest in the subject, as shown by making queries in these sessions, and interaction with teachers and peer
- Active participation, as shown by volunteering for presentation, and performance during discussion.
- Scientific attitude, as shown by rational thinking, curiosity to clarify doubts, ability to discuss and draw conclusions.
- Inter-personal skills, as shown by attitude of accepting mistakes, understanding other's point of view and non-argumentative behaviour.

Thus internal assessment is not a snap-shot observation but a matter of multiple observations by a number of observers, making it a continuous process, inextricably linked with teaching-learning activities.

The internal assessment marks contribute 20% of the total score of the final summative examination and are equally divided between theory and practicals. This is in line with the MCI guidelines on graduate Medical Education (10), which has placed much emphasis on internal assessment. In addition, students are given the 'mock-examinations' at regular intervals, which are in fact the practice

examinations for they do not carry any marks. However, the pattern of question papers and assessment tools is exactly the same as the real-examination so that the students get adequate practice and exposure.

Final summative examination: The final summative examination, held at the end of the first year and second year of Phase I, consists of theory and practical components. Every possible attempt is made to reduce subjectivity and bring in more objectivity. The questions are framed clearly and according to the learning objectives already specified. In general, each question or practical exercise may be taken as a precise task that is interpreted identically by various observers. In theory the multiple choice (MCQ), short answer type (SAQ), and modified structured essay questions (MEQ) are included. The correct pattern of answer and the scoring pattern is predetermined for each type of question so that there is little ambiguity and the unacceptable inter-examiner variation (11). MCQs may be of single answer, multiple response or reason-assertion type and SAQs may be a word, sentence or a paragraph (12). There are four theory papers, each paper covering related organ systems. Different disciplines contribute questions to each theory paper; the number of question a given discipline gets to contribute is according to the number of teaching hours earlier allotted to it in that organ system(s). For example, biochemistry is allotted about 15% of the total teaching hours during endocrinology, and gets to contribute about same percentage of questions in this system.

Evaluation of practical skills, which are very subjective at most places, have been made student-centered, structured and are objectivized to the extent possible. Accordingly, they are named as *Objective Structured Practical Examinations (OSPE)*. Adapted from objective structured clinical examination (OSCE) in conjunction with the conventional examination, the OSPE represent an upcoming concept in assessment of the student's skills in laboratory sciences; and his ability to observe and analyze (13). All candidates of a batch/class are assessed on the same set of questions (called stations)- each station presenting a definite task to the student, to be performed in a specified time. The stations can be a) *performance station* (Appendix I) where the student performs a procedure, mostly a qualitative test and may be observed by the examiner with the help of a checklist;

or b) *question station*, which tests knowledge related to a given aspect of laboratory sciences (Appendix-II). The questions are structured in such a way that different elements of the exercise are assessed, each element receiving the desired weightage. Some of the commonly used question stations in biochemistry are interpretation of a given short clinical history and/or biochemical profile of a patient, interpretation of an electrophoretic pattern, identify whether a given test is positive in the given test tube or slide and to interpret it. Together these question stations offer advantage in being able to test knowledge encompassing various aspects of laboratory sciences in a relatively short time. The performance stations on the other hand serve as additional assessment tools for testing the psychomotor practical skills. To increase objectivity, marks are allotted for every correct step of the given laboratory exercise.

Evidently, this method of examination (OSPE) is an objective one, reliable, and on the whole, less time consuming. It scores over the traditional method of assessment in our examination systems where the examiner comes into picture only after completion of the test and thereby mostly gets to see only the end result. Thus the emphasis during OSPE shifts from *product to process*.

Vive-voce examinations are also standardized to minimize the chance factor.

It is a matter of common experience that evaluation determines the way in which the students study despite anything teacher may say about the goal of a course- a corollary of it being that what is not being evaluated will not be learnt (10). Keeping this in view the evaluation tools in BPKUHS, described above, have been designed so as to address all domains of learning, e.g., knowledge (including ability to critically analyze), skills and positive attitude.

Epilogue: The BPKUHS has provision for constant evaluation of teaching methodology and quality of teaching-learning tools and resources. Workshops are regularly held where experts in the field of Medical Education from India and Nepal, and WHO consultants are invited for imparting training to the teachers to practice this new system of medical education. The teachers in turn have benefit of putting into practice the newly learnt concepts in this innovative curriculum. Students-feedback reports have shown that they find biochemistry

clinically relevant and extremely useful in understanding and analyzing clinical problems. Since only one batch has graduated under this program, it is as yet premature to emphatically examine impact of the new curriculum in the health service sector. However, vibrant nature of the curriculum has succeeded in stimulating interest of the students as well as the teachers who have been showing keen interest and enthusiasm in the

teaching-learning activities. Emphasis on development of skills in self-directed learning and problem solving is hoped to be useful in the long run as well. If proved effective, the curriculum may serve as a model for the medical education in India where the MCI has stressed upon a need-based curriculum (14). It is very much hoped that the futuristic outlook of this contemporary curriculum will stand the test of time and would be taken positively by other medical institutions.

APPENDIX I- EXAMPLE OF A PERFORMANCE STATION (Benedict's test)

Observation checked	Marks (10)
• Picks up a dry test tube from the test tube rack	1
• Correctly pipettes out 5ml of Benedict's solution	1
• Heats the tube over flame and observes change in colour	1.5
• Puts 8 drops of urine in the test tube	1
• Mixes well and heats the test tube over flame and looks for change in colour, if any	1.5
• Reports his observation immediately in the answer sheet	1
• Keeps the reagent bottles, pipettes, tubes etc. in place and cleans the table before leaving for the next station. (2 marks are given for the correct test result).	1

APPENDIX II- EXAMPLE OF QUESTION STATION:

Marks = 5

Thyroid profile of a 42 year-old woman complaining of cold intolerance and weakness showed:		
Hormone	Serum level	Reference range
T ₃	0.6 ng/ml	0.75-2.2 ng/ml
T ₄	3.2 mg/ml	5.5-12 mg/dl
TSH	10 µIU/ml	0.3-5 µIU/ml
1. Comment on the thyroid status. 2. Mention the expected serum cholesterol level in this case (increased/ decreased/normal). 3. State the possible mechanism of rise in serum TSH level in this case.		

REFERENCES

1. Paul, V.K. 1993 Innovative programmes of Medical Education : Case studies. *Indian J Pediatr*; 60: 759-768.
2. World Health Organization global strategy for health for all by the year 2000. Health for all series (no.3). Geneva: 181;23.
3. The Edinburgh Declaration: World Congress on the Medical Education of the World Federation of Medical Education 1988; *Med Edu* 22: 481-482.
4. Harden, R.M., Sowden, S. and Dunn, W.R. 1984; Educational strategies in curriculum development: The SPICES model. *Medical Education* 18: 284-297.
5. Medical Education for Twenty First Century: A brief report. Proceedings of the International Conference on Medical Education, Dharan, 12-14 December 1993, *J Inst Med* 1994; 16: 94-1-1.
6. Koirala, S., Kumar, N. and Upadhyay, M. 1994; Institutional goals and philosophy of BP Koirala Institute of Health Sciences, Ghopa Dharan. *J Institute Medicine* 16: 1-4.
7. The first version of the MBBS curriculum of BP Koirala Institute of Health Sciences, Ghopa Dharan, Nepal 1996.
8. Jayawickramrajah, P.T. 1993; Impact of problem-based, integrated medical curriculum on students approaches to learning. *Baharin Medical Bulletin* 15: 116-121.
9. Clement, D.E. 1971 Learning and retention in student led discussion group. *J Social Psychology* 279-281.
10. Singh, T., Singh, D. and Natu, M.V. 1997. A suggested model for internal assessment as per MCI guidelines on graduate Medical Education. *Indian Pediatrics* 35: 345-347.
11. Bonney, R. Objective Testing in Education and Training, 1st Edn. London, Pitman Education Library, 1973.
12. Verma, M., Chhatwal, J. and Singh, 1997; T. Reliability of essay type questions : effect of structuring. *Assessment Higher Education* 4: 265-270.
13. Nayar, U., Malik, S.L., and Bijlani, R.L. 1986; Objective Structured Practical Examination OSPE : A new concept in assessment of lab exercises in pre-clinical sciences. *Medical Education* 20 : 204-209.
14. Medical Council of India: Guidelines on Graduate Medical Education. New Delhi, Medical Council of India 1997.

TABLE I: Curriculum Strategies

	SPICES model	Conventional model
1.	Student centered	Teacher centered
2.	Problem-based	Information gathering
3.	Integrated	Discipline based
4.	Community based	Hospital based
5.	Elective	Standard program
6.	Systematic	Opportunistic

Fig. 1. Conceptual framework of the MBBS program at BPKUHS

- Unit I – Basic Concepts
- Unit II – Cardiovascular & Respiratory Systems
- Unit III – Endocrinology
- Unit IV – Genitourinary System, Acid-Base Chemistry & Molecular Biology
- Unit V – Skeleto-Muscular System & Haematology
- Unit VI – Central Nervous System