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Original Article

A crossover comparative study to assess efficacy of competency based medical education (CBME) and the traditional structured (TS) method in selected competencies of living anatomy of first year MBBS curriculum: A pilot study

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ABSTRACT

Background: Competency based medical education (CBME) is outcome based teaching methodology where a student learns a set of measurable competencies for early clinical exposure. In spite of ample resources on CBME, there are limited studies on its implementation. This study will try to demonstrate improvement in the performance of students using CBME as a teaching tool over the traditional structured method (TS).

Methods: Forty student volunteers were chosen and divided into two groups. The crossover design exposed the group of students to CBME and TS spread over two periods with a wash out period in between. The intervention group was exposed to selected list of competencies in living Anatomy with feedbacks and formative assessments. The summative assessments were held at the end of each period.

Results: The mean scores of CBME and TS in group 1 is 130.625 and 113.65 while in group 2 is 139.425 and 112.075 respectively. The treatment and period effect is significant. Estimate of treatment effect is 22.1625. The average improvement in treatment scores is by 11%. Two tailed paired sample T test reveals significant improvement in the scores post intervention.

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Conclusion: CBME method produces better performance of the students in the competencies of living anatomy.

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Introduction

Competency based medical education (CBME) was first mentioned by Mc Ghahie in 1978.¹ The CBME curriculum is organized around competencies with specific knowledge objectives, training of students to perform basic measurable activities, progression in smaller cumulative steps and de-emphasize time based training with formative feedbacks.^{1–4} It is often referred to as the second Flexnerian revolution in medical education.⁵ The curriculum is outcome based and learner centric unlike the traditional structured (TS) teaching followed in most of the medical schools.⁵ It has its origins in the need for an accountable, responsible and a competent doctor who can satisfy the societal aspirations of a trustworthy medical service. Carraccio et al. and Leung^{5,6} pioneered the components of competencies, identification of performance levels, assessment and evaluation strategies and guidelines on criterion based pass standards. The pioneering programmes in US (ACGME 2001), UK (GMC Competency framework 1993), Scotland (Scottish Doctor), Canada (CanMed), Australia and Netherlands (National undergraduate framework)^{2,4} are based on CBME. The American council for graduate medical programme (ACGME) mention achievement of milestones to evolve from a novice to an expert.⁷

In CBME a learner is expected to learn a set of competencies integrating multiple domains of knowledge, skills, attitudes and communication within the cultural and social contexts.^{8,9} It focuses on affective and cognitive domains and inculcates leadership qualities amongst competent clinicians. Unlike the typical de-emphasized time based training, Levine et al.¹⁰ also proposed a 'hybrid time' model with a fixed time frame in his study on Anaesthesia trainees. The competencies are judged by Miller's pyramid with formative assessments, feedbacks and use of assessment matrix which relates each assessment back to the relevant competencies.^{11,12} Criterion based assessment; a hallmark of CBME emphasizes milestones as a determining factor to gauge the learning trajectory of students. Assessment tools like MiniCex, audit, multi-source feedback, simulation, OSPE, OSCE, etc. are some which are most often used.^{3–5,11}

The primary aim of CBME is to inculcate leadership qualities amongst budding clinicians, help in policy formulation and become effective 'change agents' of the future. The traditional method has produced health workers with requisite qualifications, but without the necessary competencies to perform varied tasks.

Medical Council of India (MCI),¹³ the apex body on Medical education in their 2011 document 'Vision 2015' and again in the new Graduate Medical Education regulations 2012^{4,14} have stressed the need for restructuring the undergraduate medical education with a programme designed to create an 'Indian

Medical Graduate'. The 'Indian Medical Graduate' will have the necessary competencies (knowledge, skills and attitudes) to assume his or her role as a health care provider to people of India. The document mentions the inclusion of a foundation course in the first MBBS where the student will be oriented to various skills on cognition, communication and ethics to name a few. The horizontal and vertical integration with an early clinical exposure is integral to development of competencies in CBME.

There has been lot of literature on CBME, but only handful of studies to assess its efficacy. The few studies which have analyzed the comparisons of the two methods have been done abroad but none reported from India. The traditional teaching in India stresses on knowledge acquisition, inadequate training on motor skills while soft skills like attitude and communication are learnt in the final years and beyond, which makes the graduate student less likely to provide holistic health care in real life situations.⁴ CBME studies done by Dunnington et al.¹⁵ and Kerdijk et al.¹⁶ on undergraduates revealed differing outcomes. The conflicting findings with a shallow repertoire of investigative studies are prime reasons why this pilot project may be an important contribution to present literature.

The study aims to assess the efficacy of this new methodology in teaching and evaluate the students for any measurable improvement in their physical skills, knowledge, attitude and communication in some competencies of living Anatomy. It also envisages designing relevant assessment and feedback mechanisms as its primary objectives. It may be hypothesized at this juncture; post intervention there may be a perceptible change in the performance of the students.

Material and methods

The study was performed on forty randomly selected volunteers from the batch of First year MBBS. The students were then divided into two groups of twenty each (group-1 and group-2) serially as per their roll numbers. The sample had no specific inclusion or exclusion criteria as the students were selected from a baseline cohort of First year MBBS students with similar age, knowledge and skills. Institutional ethical committee consent was received before the study commenced. Informed consent was taken from the participating students.

Focus group discussions were conducted and attended by all stakeholders to discuss the goals and objectives of the study, its methodology and assessment tools. The faculty finalized the multiple choice questions, selected list of competencies and streamlined assessment and evaluation protocols. The multiple choice questions were selected from the prevalidated question bank of the institution. The competencies were selected from five categories of superior

and inferior extremities with similar difficulty level and validated by senior faculty (Table 1). The faculty and support staff underwent mock training and simulations on teaching and assessment protocols to be followed during the study. The teaching learning tools used were didactic lectures, dissections and tutorials for both the experimental units.

Crossover design was selected for the study. It followed 2 sequences (AB, BA pattern), 2 period design analyses, where A and B represented specific interventions while the period represented the time-spread of each intervention. The experimental units cross over from one exposure to another after the wash out period. Crossover designs have less influence on confounding covariates (as each experimental unit serves as her/his own control), have better statistical efficiency and require fewer subjects.¹⁷ The experimental units randomized to sequence 1 (AB) for group 1 students were exposed to intervention A (CBME) in Period 1 (P-1) followed by intervention B (TS) in Period 2 (P-2) post wash out period. Similarly, in sequence 2 (BA), students of group 2 were exposed to intervention 'B' followed by 'A' in P-1 and P-2 respectively. The TS cohort is the control in this study.

The group undergoing intervention was taught living anatomy and demonstrations of selected competencies with regular and real-time feedbacks. As the study had been embedded with the curriculum followed in the department, P-1 consisted of competencies from superior extremity while competencies from Inferior extremity were taught in P-2. The students of intervention group were made aware of the expected end outcomes, acquisition of skills, knowledge, attitude and communication through formative assessments and regular feedbacks.

A set of competencies were finalized based on regions and categories after needs assessment (Fig. 1). The specific learning objectives, the construct, the domain and the level of assessment were identified and validated. For evaluation of the competencies, two types of assessments were followed. For the students in a particular sequence, only the CBME group was exposed to formative feedbacks and assessments in addition to summative assessments applicable for both intervention types at the end of each period. However, the interventions in a particular sequence were separated by a washout period of 2 months to prevent any carryover effects. The assessments of P-1 were completed before the washout period while assessments for P-2 were conducted after the washout period. The formative assessments and feedbacks for the intervention group included demonstrations, 1 min paper questions and MiniCex. The MiniCex evaluation form was modified as per the requirement of the study and the questions on clinical parameters were excluded. Subsequent-

ly, feedbacks were provided to the students as per the rating scale with specific comments if any. Similarly the 1 min paper was used to assess the understanding of the subject during real time classroom discussions and the feedback was given on the difficult aspects of the topic. These methodologies were embedded into the tutorials, dissections and small group teachings of the intervention group.

The summative assessment was conducted through MCQs and objective structured physical examination (OSPE). It was done at the end of each period for both the groups. The MCQ test was conducted for all students on one day. One OSPE station was made for each category of competency to be tested from inferior and superior extremities (Table 1, Fig. 1). The demonstration of the physical skills and other domains were assessed against a standardized checklist and the assessment for the two groups was spread over two days. For example, on day 1, all students of P-1 from group 1 were assessed while day 2 was for group 2 students. Each examiner in the station assessed one category of competency on domains related to knowledge, motor skills, attitude and communication. Before the OSPE was conducted, adequate signages, circuit maps, questionnaires and instructions for the students, check list of skills to be tested and living subjects were placed in the stations. The stations were manned by a faculty member while two residents in attendance conducted the proceedings. The competencies were assessed at the 'shows how' level of Miller's pyramid.¹¹ The results of the MCQs and the OSPE were collated in an excel sheet and evaluated. The test scores of the two groups were statistically measured using the methods employed specific for crossover design¹⁷ to gauge significance of treatment effect (i.e. the intervention), the period effect and interaction.

At the end of the study, the students were asked for a feedback on CBME with sixteen questions and three open ended questions. The feedback questionnaire with individual comments was adapted from the University College, Dublin. The questionnaire was based on Liekert's scale from strongly agree to strongly disagree.

Results

The result of the study indicates significant improvement in the scores of students with CBME intervention. The mean difference of scores of Sequence 1 pertaining to Group 1 (Table 2) is 16.975 (SD: 9.764) while the mean sum of scores being 244.275 (SD: 23.347). The mean difference of scores of Sequence 2 pertaining to Group 2 (Table 3) was -27.35 (SD: 13.291) while the mean sum of scores being 251.5 (SD: 20.788).

Table 1 – Category wise list of competencies related to regions from superior and inferior extremities.

Competency category	Regions from where competency selected	
	Superior extremity	Inferior extremity
Joints	Shoulder joint, elbow joint	Hip joint, knee joint
Muscle	Biceps Brachii, muscles of palm	Calf muscles
Nerves	Ulnar, median	Femoral, sciatic, common peroneal
Artery	Radial, brachial	Femoral, Dorsalis pedis
Landmarks	Cubital fossa	Midpoint of inguinal ligament, mid inguinal point

Fig. 1 – OSPE stations (stn) with sample blueprint. The OSPE was conducted with five stations, each assessing one category of competency.

The statistical results for cross over design study produces no significant test of interaction ($p = 0.3079$). The treatment effect is significant with $p < 0.05$ at 0.0000. The period effect is significant at $p < 0.05$ at 0.0077. Estimate of treatment effect is 22.1625 with CI of 18.429 to 25.8952 (Table 4A). The estimate of treatment effect suggests that the average mark of intervention group exceeds the control group by minimum of 22.

Individual assessment of domains using two tailed paired T test reveals significant improvement in the scores in MCQs and skills spread over both sequences and periods. However the extent of difference in the performance is higher in Sequence 2 in comparison to sequence 1. The mean scores are higher in the CBME session for group 1 P1 and group 2 P2 (Table 4B).

The scatter plot of sum and difference (Fig. 2) indicates a positive correlation to the intervention with the carryover effect slightly pronounced in sequence 1 plot. The sum is slightly skewed to the right with higher scores in the y axis in Sequence 2 suggesting better performance with the intervention. The spread in sequence 1 is less than sequence 2, suggesting some effect of carryover effect. The Box and whisker plot indicates better performance in groups with intervention (Fig. 3). The Bar diagram on student feedback (Fig. 4) elicits responses with majority agreeing on the concept of CBME, opportunity for group work and individual participation.

Discussion

The society demands dependable and efficient health care. The medical education has been imparted over centuries based on didactic classes with a teacher centric curriculum. Students are expected to learn the nuances of medicine over a fixed period of time and the graduation is based on summative exams which assess his knowledge. In spite of the traditional method of medical education having served its purpose, there are concerns regarding deteriorating standards and ethics amongst the present day doctors. CBME stress on multi-domain outcome based medical training to produce trustable medical practitioners and satisfy societal aspirations.

Few studies have been done on implementation of CBME as mentioned before. A study by Dunnington¹⁵ in 1994 for assessment of clinical skills in surgical clerkship using competencies indicated an improvement in skills on physical exam, physician patient relationships and patient write ups but correlated poorly with knowledge acquisition. In another study by Kerdijk et al.¹⁶ in 2013, revealed an opposite facet and concluded the new curriculum did not produce students fit for medical practice. A newly formulated CBME curriculum in basic sciences has been tried in an African medical school. It

Table 2 – Showing the performance of the students of group 1. 'd': difference of the marks obtained, 'e': sum of the performances.

Group 1 S no.	CBME (A) – P1 Max marks 200	TS (B) – P2 Max marks 200	d	e
1	140	110.5	29.5	250.5
2	118.5	104	14.5	222.5
3	131.5	118	13.5	249.5
4	140	112	28	252
5	110.5	97.5	13	208
6	135.5	117.5	18	253
7	124	103.5	20.5	227.5
8	143.5	117	26.5	260.5
9	155	125	30	280
10	113	101	12	214
11	134.5	125.5	9	260
12	108	96.5	11.5	204.5
13	132	126.5	5.5	258.5
14	104	100.5	3.5	204.5
15	133	130.5	2.5	263.5
16	151	119.5	31.5	270.5
17	136	107.5	28.5	243.5
18	138	133.5	4.5	271.5
19	140.5	115.5	25	256
20	124	111.5	12.5	235.5
Mean	130.625	113.65	16.975	244.275
SD	14.04867	11.0835	9.76362	23.3472

Table 3 – Showing the performance of the students of group 2. 'd': difference of the marks obtained, 'e': sum of the performances.

Group 2 S no.	TS (B) – P1 Max marks 200	CBME (A) – P2 Max marks 200	d	e
1	102	131	–29	233
2	101.5	125.5	–24	227
3	85.5	142.5	–57	228
4	107.5	155.5	–48	263
5	116.5	126	–9.5	242.5
6	117	141.5	–24.5	258.5
7	128.5	137.5	–9	266
8	113	151	–38	264
9	114.5	163.5	–49	278
10	106.5	130	–23.5	236.5
11	126	144.5	–18.5	270.5
12	100	120.5	–20.5	220.5
13	109	137	–28	246
14	104.5	110.5	–6	215
15	112.5	132	–19.5	244.5
16	128.5	163.5	–35	292
17	112	144	–32	256
18	126	152	–26	278
19	115	144.5	–29.5	259.5
20	115.5	136	–20.5	251.5
Mean	112.075	139.425	–27.35	251.5
SD	10.71801	13.7671	13.2914	20.7884

has shown encouraging results but the final evaluation of the outcome is still awaited. The curriculum in Anatomy was horizontally integrated with physiology and biochemistry.¹⁸

This study however indicates an overall improved performance by the students from the intervention, though done at a smaller scale. The preliminary results may be an indication of its promising future and with multitudes of confounding factors, limitations and biases as experienced during this

study, it may perhaps explain some of the variations in outcomes with previous studies. In both the sequences, the intervention group performed better than their counterparts in the control group and more specifically the sequence 2 students performed marginally better than their counterparts in sequence 1 (Table 4A, Fig. 3). The mean scores of TS group are similar with a marginal better performance in sequence 1. The marginally higher performance may be due to better

Table 4A – Showing the mean of the marks obtained, mean of the difference of the marks (Mean 'd'), Standard deviation of 'd' and test of treatment effect.

Seq & groups	Period 1 Mean score	Period 2 Mean score	Mean (d)	SD (d)
1 (n = 20)	130.625	113.65	16.975	9.763621
2 (n = 20)	112.075	139.425	–27.35	13.29137
		t-Values		p-Value
Test for interaction		–1.03359		0.3079
Test for treatment effect		12.01955		0.0000*
Test for period effect		–2.81337		0.0077*
Degree of freedom (df)			38	
Estimate of treatment effect			22.1625	
95%CI			18.429778–25.89522	

Table 4B – Showing the results of the paired sample T test for means for MCQs and skills of the two sequences. D (P1 – P2) indicates the difference in performance (the CBME intervention for Seq 1 Grp 1 is P1 while for Seq 2 Grp 2 is P2).

		P1	P2	D(P1 – P2)	T statistic
Seq 1	MCQ mean	73	64.25	8.75	7.676*
Group 1	Skills mean	57.63	49.4	8.23	4.876*
Seq 2	MCQ mean	64.75	77.25	12.50	–10.162*
Group 2	Skills mean	47.32	62.18	14.86	–6.783*

* Statistically significant.

performance in the skills category which in turn might be due to the first order carryover effect of sequence 1 (Table 4B). Sequence 2 did not have any carryover effect as the intervention was in P2. There is a marked improvement of skill performance in sequence 2, P2 in relation to the sequence 1, P1 (Table 4B). This might be explained by the intervention with formative feedbacks and its positive uptake by the students and a possibility of contamination arising due to intermingling of the students between two groups. The depreciation in the skills mean in the sequence 1, P-2 may be explained by the return to the pre-intervention attitude and the effect of washout period. The treatment effect is significant and it disapproves the null hypothesis (Table 4A). It indicates an approximately 11% improvement in performance post intervention. In addition to the summative assessment, the students were given an opportunity for a feedback (Fig. 4). Majority agreed that CBME and feedback reinforced learning and opportunity for individual participation was more useful for the whole process. Majority of the students appreciated the practical relevance of the competencies and the importance of affective domain which will be a major factor in their later years of medical practice. The feedback on teacher bias showed an interesting trend; the majority neither agreed nor disagreed but eleven students felt there was a bias. It is quite possible the participating faculty may have been biased towards the new methodology and may have followed practices in his teaching with an inner desire for the intervention to show significant results. Elimination of teacher bias is a challenge and it may not always be practical to request faculty from other institutions blinded to the objectives of the

Fig. 2 – Plot of sums and differences. X axis: sum of each subject's two responses on the horizontal axis. Y axis: difference between each subject's two responses on the vertical axis. Blue plots: seq 1, Red plots: seq 2. Separation of plotting symbols along horizontal line represents the size of the carryover effect. Separation of plotting symbols along vertical line represents the size of the treatment effect. Outliers are easily detected on this plot. The study shows a positive correlation in the two sequences.

study. The competencies were repeated for the non participating students after the study to prevent performance bias during final exams.

There are limitations to this study. The competencies need more stringent evaluation for its validity and reliability over time. Too much objectivity in assessments maybe a bane for CBME as competencies develop over time and need subjective interpretations during assessments but these are again open to bias by the examiner. The bias in this case may be overcome by assessing the examiners for their internal consistency with a temporal and spacial spread in real life simulations.⁴ CBME needs a thorough training of the faculty and it is quite possible during the assessment, the examiner may have been biased towards either of the curriculum being tested. To prevent the bias from manifesting in the results, a group of teachers not related to the project may certify the examiner and may also be allowed to witness the proceedings, but there may be objections from senior examiners. The statistically significant

Fig. 3 – Box and whisker plot. X axis: indicates sequence and groups, Y axis: score. The median and spread of the CBME groups are more than the TS with its performance skewed towards higher scores. The results indicate an overall better performance by the CBME group with no marked difference in the scores of TS groups.

Fig. 4 – Student feedback. X axis: response from 5 to 1 in a Likert's scale from strongly agree to strongly disagree. Y axis: the number of students with the particular response.

results coupled with improved performance post intervention needs to be examined for presence of teacher bias. The teacher bias was expected to be removed by the same teacher teaching all the topics but it was not possible as some of the teachers were not available due to official commitments and this study has been conducted for a small sample size for one particular batch of students spread over just six months. As mentioned before the carryover bias of crossover design is well known and it may have played a role in sequence 1 of the study. The period effect is significant and may be due to two different topics being taught in the same period. The possibility of bias arising due to two different teachers teaching two topics cannot be ruled out. Feedback from the faculty and support staff could not be taken and will be considered in the sequel to this study. In spite of the various studies, the limitations of CBME cannot be overlooked and more robust studies need to be done for its final acceptance. With its primary objective of learning competencies, skills and attitudes and a seemingly less emphasis on concepts and principles, 'medical education' may just well be reduced to 'medical training' in case the medical fraternity is not careful.^{7,19}

Conflicts of interest

The authors have none to declare.

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