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Effectiveness of concept map in learning clinical aspects of biochemistry: A prospective interventional study from the Indian teaching hospital

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ABSTRACT

Introduction: We aimed to study the effectiveness of concept mapping as an effective tool in learning clinical aspects of Biochemistry.

Materials and Methods: Prospective interventional study was conducted on total 148 (n=148) first MBBS Medical Students of Government Medical College, Akola, admitted during academic year of 2018 Participants were categorised into two groups: Group I - designated as Interventional group-CM (n=74), where concept-map approach was adopted to taught clinical case based biochemistry content. Group II – designated as Didactic lecture -DL (n=74) and students were exposed with the traditional lecture-based approach to taught the same content. Responses were recorded by using questionnaire as a research tool. It includes specific questions (open and close ended questions) with the goal to understand a topic from respondent's point of view.

Results: By applying unpaired "t" test, the students in group I (CM) significantly outperformed (p-value < 0.0001) as compared to group II (DL). The mean ± SD values of the test scores to assess the academic performance in group I (CM) & Group II was found to be 13.46 ± 1.59. 10.83 ± 1.55 respectively. In addition, we also observed that students of group I performed significantly well irrespective of gender distribution as compared to Group II.

Conclusion: Present study indicates that students were able to integrate clinical aspects of biochemistry effectively by virtue of using Concept mapping as interventional strategy and assists them in correlating the clinical knowledge of biochemistry with disease symptoms by enhancing critical thinking and reasoning ability.

1. Introduction

In undergraduate medical education, teaching basic medical science courses is complicated because of the widespread use of didactic lectures (DL) by educators that are teacher-centred and encourage passive learning. It is unlikely that lecture-based teaching learning methods that have been implemented in biochemistry learning for many years are sufficiently successful to conserve memory comparable to less than 5% after 6 months.[1]

In today's era, where so much emphasize is given on the competency based medical education (CBME) to make learning more effective in terms of knowledge, skills and attitude. It seems new interventional learning strategy is must require which can promote meaningful learning and can shift paradigm from teacher centeredness conventional learning to student centric teaching learning approach. In the field of medical education, various new interventions were

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introduced in the teaching or learning new concepts.

To understand in depth concept in undergraduate education, curriculum preparation and education evaluation, Concept Mapping (CM) has been used previously.[1] Ausubel first introduced meaningful learning theory that conceptual learning takes place through hierarchical position of concepts, distinction of concepts in the cognitive framework and relation between different concepts.[2]

Joe Novak describes "concept" in events or objects as a perceived regularity, or records of events designated by a tag. A word is the tag for most concepts. In a concept map, the concepts with the most inclusive, more general concepts at the top of the map and the more specific, less general concepts grouped hierarchically below should be described in a hierarchical fashion. The hierarchical structure of a specific area of knowledge often depends on the sense in which that knowledge is used or taken into account.[3]

Many studies[4–7] described that compared to other traditional approaches, CM is a better way of acquiring knowledge base than reading, attending lectures and taking notes**.** The content to be learned must be conceptually understandable and illustrated with vocabulary and examples relevant to the previous experience of the learner. All these requirements can be met by concept maps, both by defining broad general concepts retained by the learner before training on more specific concepts and by helping to sequence learning tasks by increasingly more explicit information that can be rooted in the creation of conceptual frameworks. It is very worth noting that the rote-meaningful distinction is not a simple distinction, but rather a spectrum, since every person differs in the quantity and quality of the relevant knowledge he possesses and in the strength of their motivation to pursue ways to integrate new knowledge into the relevant knowledge they already have.[4–7] CM could be beneficial in incorporating basic and clinical knowledge and understanding new information that they acquire[8] and improving the reasoning abilities of students for student clinical preparation.[9]

Biochemistry is considered by medical students as a challenging, unpredictable volatile and difficult to remember due to its heavy content which includes several biochemical pathways with interconnected disorders. Hence, subject needs to be taught and learnt extensively and deeply conceptualized with good clinical knowledge.[10]

In the view of above, present prospective interventional study has been planned with aim to implement concept map as an interventional method and identify its effectiveness whether it is better tool in learning clinical aspects of biochemistry over traditional lecture based learning.

2. Materials and Methods

2.1. Study design

This Prospective Interventional Study was conducted for the duration of 6 months with the intervention in the form of didactic lectures and concept mapping.

2.2. Study participant & sampling and randomization

Present study included first MBBS Medical Students of Govt. Medical College, Akola, admitted during academic year 2017-18.

Step 1: All existing 1st MBBS students (n=148) enrolled to the biochemistry course during 2017-2018 academic year were categorised into two groups:

1. Group I - (n=74). Comprised of Roll Numbers 01-74 introduced with the clinical cases using concept-mapping program (Interventional group-CM).
2. Group II –(n=74), comprised of Roll Numbers 76-149 students exposed with the traditional, lecture-based program (Didactic lecture -DL).

Step 2: In the interventional group (Group I), the 74 students were further split randomly into subgroups of three (2 subgroup containing 25 participants and third 24 participants respectively) followed by further randomization of 25 participants into total of 5 small groups with 5 in each group and 4 participants remaining in last group.

For this study, a concept mapping technique with clinical cases (Group I) was used. This study was conducted from October 2017 to March 2018, before the beginning of the educational project, with due permission obtained from the Institutional Ethics Committee (IEC).

Students were given clinical cases for discussion in small groups (Group I), i.e., 5 small groups with 5 participants in each group and 4 participants in the last group, including the preparation of principle maps, all under the supervision of a member of the faculty of biochemistry. For concept mapping, as defined by Novak and Canas, the following steps were taken with little modification: 1) brainstorming stage, 2) organizing stage, 3) layout stage, 4) linking stage, 5) revising and finalizing stage.[4]

During this study, both groups of students were instructed by the same faculty member, and the students of both groups had the same amount of teaching and learning time. Note has been taken such that all groups have the potential to understand interpretation by asking the faculty member for guidance. The time gap between the teaching and learning activities and the analysis was also identical for each group.

The clinical case studies consist of a series of common medical conditions like Phenylketonuria, Heme metabolism and abnormal hemoglobins, Lesch Nyhan syndrome and symptoms, each of which was chosen for creative teaching

learning resources, accompanied by a collection of case-related questions.

2.3. Data collection method: (Tools and purpose)

Paper setting of pre-test & post-test questions and questionnaire Structuring:

1. Structure of Paper covered SAQ/BAQ/MCQ/ Single best response questions reviewed by biochemistry expert for posttest analysis.

Posttest questionnaire was framed to find out that critical thinking and reasoning skill has been developed in the students, hence post -test questions was based on clinical based case study.

Item selection for identification of perception, Questionnaire was prepared which contain 12 close-ended questions developed by using 5-point Likert's scale along with 3 open ended questions specifying advantages, disadvantages and suggestions. Questions was validated by faculty members of department of biochemistry / peer group MBBS, GMC, Akola for suitability and clarity of the content.

Table 1: Clinical case studies selected for study

Selected for study	**Teaching tools employed**	
Heme Synthesis and related disorders	**Group I**	**Group II**
Metabolic Disorders of aromatic amino acids.	• Interventional Program # Concept mapping (CM)	• Traditional program # Didactic Lecture (DL)
Gout & Lesch Nyhans Syndrome		

Using the scores from the three post-module written tests, student success was evaluated. Multiple choice questions (MCQs), brief questions (BAQs) and SAQs were part of the exam. The highest score for each test, on average was 20Marks.

2.4. Data analysis method

Data was collected and entered in MS Excel sheet and by using descriptive and inferential statistics using z-test for difference between two means and software using the analysis was epi info 6. p value < 0.05 was considered as level of significance.

The CM group students were asked to complete 12-item, 5-point Likert Scale Questionnaire on their interpretation of the utility of the concept-mapping method in accordance with the arena of clinical cases, which was prepared on the basis of the guidance reported by Pinto and Zeitzz.[11] The questionnaire assessed: a deep understanding of the subject matter, the importance of the events, discussion opportunities, the use of critical thinking, the effectiveness of concept mapping, the relevance of potential practice, the promotion of self-assessment (self-directed learning), the promotion of active learning, the capacity to learn, the meaningfulness of learning and the role of teachers. The usefulness of CM as a powerful learning method and its advantages and drawbacks were therefore qualitatively assessed in terms of the percentage of their responses to each of the items.

2.5. Ethics

Study was started after Institutional ethical committee approval and informed consent of first MBBS students was taken before commencement of the study.

3. Results

When compared test score between male and female Group I, & II., Student of group I performed significantly well irrespective of gender distribution as compared to Group II. (Table 3 A & B)

As Table 4 results highlights the perceptions of students for various close ended questions. Most of the student felt that (Table 4) the clinical cases were fascinating and enabled constructive teaching. They also considered that they could competently incorporate the knowledge and relate the fundamental concepts of biochemistry in terms of the clinical problem through concept mapping., 90.54.%. They appreciated the sharing of ideas that took place in the small group clinical case discussions accompanied by the development of concept mapping activities in small groups thus allowing biochemistry to be far more enjoyable. Performing task motivated them towards self-directed learning (79.73%), encouraged successful learning and facilitated in interpreting biochemistry's clinical content compared to that of conventional teaching in the classroom (78.37%). Our data are in accordance with earlier results.[12,13] Group I Participants also felt that the role of the teacher as mediator is the main factor in the correct conduct of these concept mapping sessions in small groups (92%). 95.95% participants confirmed case study by virtue of CM helps them in improving critical thinking in learning clinical aspects of biochemistry. However, 4.05% were partly agreed with the same.

Majority of participants felt CM program as valuable educational tool to revise, retain topic content before final examinations (82.43%), promote active learning (97.29%), create interest in learning (94.59%) are in line with study conducted by Krishna M. Surapaneni.[14]

3.1. Students response to open ended questionnaire as shown in (Table 5)

1. Student found CM program as time consuming (79.72%) and effectivity is dependent on facilitator conducting the session (85.13%).

Table 2: Test score analysis in group I (Concept Mapping) and group II (Didactic Lecture)

Groups	Mean ±SD	Standard Error of Mean (SEM)	Two-tailed P value
I (CM) n=74	13.46 ± 1.59	0.185391	< 0.0001 (Highly Significant)
II (DL) n=74	10.83 ± 1.55	0.180315	

SAQs, MCQs, BAQs were administered and test score were analyzed in both groups and unpaired t test was applied /As Shown in Table 2: the students of group I (CM) significantly outperformed (p – value < 0.0001) as compared to Didactic Lecture Group II DL).

Table 3: Gender wise comparison of test scores between Group I (Concept Mapping) And Group II (Didactic Lecture)

A: Test Scores Comparison Between DL Vs CM Female Participants		B: Test Scores Comparison Between DL Vs CM Male Participants	
GROUP	**MEAN ±SD**	**GROUP**	**MEAN ±SD**
DL Female participant N=30	10.85±1.60	DL Male participant N=44	10.79±1.540
CM Female participant N=29	13.24±1.76	CM Male participant N=45	13.61±1.476
P value and statistical significance: The two-tailed P value is less than 0.0001. By conventional criteria, this difference is considered to be extremely statistically significant. Confidence interval: 95% confidence interval of this difference: From -3.2663 to -1.5137		P value and statistical significance: The two-tailed P value is less than 0.0001. By conventional criteria, this difference is considered to be extremely statistically significant. Confidence interval: 95% confidence interval of this difference: From - 3.45546 to -2.18454	

2. Proper guidance will assist construction of concept mapping more fun. (83.78%).
3. However, suggestions given by participants (90.54%) opine that teacher should incorporate both conventional and concept mapping simultaneously as tool to learning more effective.
4. Self-motivation is key player to get precise knowledge and deep understanding of topic concept.
5. They opined that CM implementation might be helpful for other preclinical basic medical science subject also. (Table 4).
6. Student perceived CM as more interactive (72.97%) by performing task-based CM construction performed in small groups, thereby promote to build interpersonal relationship among teachers and fellow students (78.37%) and Create positive attitude towards learning biochemistry (74.32%).

4. Discussion

In medical education, the use of concept mapping needs to solve a need for learning process.[2,3,11]

The inventor of concept mapping, Joseph Novak, examined his work, stressing the contribution of this tool to active knowledge[4]. Concept maps are graphical representations of similar concept structures in any field, designed to demonstrate the connections between them and the entire system, enabling each connection to be interpreted.

The process of creating a concept map will enable the establishment of a cognitive learning process in which the student independently arranges his/her knowledge, defines the acquisition of new pieces of information in an oriented manner, and then incorporates them into his/her previous knowledge. It can be used by the student as a learning method to prepare notes, to solve clinical problems, to schedule teachers' study classes and/or to write long papers, to prepare tests, and to define the link with topics.[2–4]

While designing the concept map, learners should concentrate on content from previously learned topics and incorporate each concept by linking words to each other.[15] For constructing proper accurate map, learner need to be more attentive in lectures to comprehend the material which in turn assists them to become effective enough to gain in depth knowledge about topic content and thus eventually helpful to promote meaningful learning.[8,9,16–18]

In the present study emphasis was given on task by virtue of constructing concept map on modules selected on learning clinical aspects of biochemistry. Present study findings indicated that group I exposed with interventional group showed outstanding performance with significant gain in test score as compared to group II. Findings of ours are in line with work reported by earlier researchers.[17,18] However, the results are contrary to many reports, which showed no substantial difference between intervention and control groups in students' scores.[19,20]

Present study indeed confirmed that learner is able to integrate clinical interrelationship of biochemistry with disease and facilitate learning effectively via CM task which are in accordance with study carried out by Mukhtiar Baig et al.[18]

Regarding Students' perception about CM, student is agreed with utility of CM in gaining in depth understanding of information, improves meaningful learning. Our study furthermore supported by Pinto AZ[11] where he said that the concept mapping method externalizes the concepts in the current information system of the student, misunderstandings, flaws in that structure can be found. Correcting these mistakes leads to an even greater understanding.

Table 4: Student's perception for closed ended questions regarding concept mapping

Questionnaire	5-point Likert' s Scale	Number of students (N=74)	Percentage
1. Do you think CM program conducted by faculty is satisfactory?	5. SA (Strongly Agree)	23	31.08 %
	4. A (Agree)	44	59.45 %
	3. N (No response)	07	09.45 %
	2. D (Disagree)	00	——-
	1. SD (Strongly disagree)	00	——
2. Do you think CM is beneficial for a detailed understanding of the subject?	5. SA	58	78.37 %
	4. A	16	21.62%
	3. N	00	———
	2. D	00	———
	1. SD	00	———
3. Do you think CM helps in retaining Information more effectively?	5. SA	61	82.44 %
	4. A	13	17.56 %
	3. N	00	———
	2. D	00	———
	1. SD	00	———
4. Was the clinical case scenario helps to integrate and promote meaningful learning by virtue of CM?	5. SA	67	90.54 %
	4. A	07	09.45 %
	3. N	00	———
	2. D	00	———
	1. SD	00	———
5. Do you think CM motivating you towards self-directed learning?	5. SA	59	79.73 %
	4. A	14	18.92 %
	3. N	01	01.35 %
	2. D	00	———
	1. SD	00	———
6. Do you think CM used for case study can help to enhance critical thinking?	5. SA	71	95.95 %
	4. A	03	04.05 %
	3. N	00	——-
	2. D	00	———
	1. SD		———
7. Was CM increases your interest in learning biochemistry than the traditional way of learning?	5. SA	70	94.59 %
	4. A	03	04.05 %
	3. N	01	01.36 %
	2. D	00	———
	1. SD	00	———
8. Was active learning is promoted effectively by CM?	5. SA	72	97.29 %
	4. A	02	02.70 %
	3. N	00	———
	2. D	00	———
	1. SD	00	———
9. Do you think CM can you help to improve performance in Examination?	5. SA	70	95.59 %
	4. A	04	05.41 %
	3. N	00	———
	2. D	00	———
	1. SD	00	———
10. Do you feel CM facilitate the development of knowledge structures for clinical reasoning?	5. SA	72	97.29 %
	4. A	02	02.71 %
	3. N	00	——-
	2. D	00	———
	1. SD	00	———
11. Was CM an effective tool to study and revise the topic content during final examination?	5. SA	61	82.43 %
	4. A	13	17.57 %
	3. N	00	——-
	2. D	00	———
	1. SD	00	———
12. Is implementation of CM is possible in today's MUHS curriculum design.	5. SA	39	52.70 %
	4. A	20	27.02 %
	3. N	15	20.27 %
	2. D	00	———
	1. SD	00	———

Table 5: Perception of participants for Open ended questions: Overall Opinion, difficulty encountered, Suggestions about CM implementation

	Opinion of Students for (Open ended questions) N=74	Number of students (n=74)	Percentage (%)
Disadvantages	1. Time constraint. (More time consuming)	59	79.72
	2. Facilitator required more for practice and is key player in making CM as effective program	68	92
	3. Facilitator should have enough knowledge to construct CM so as to make session interesting.	63	85.13
	4. Require deep subject knowledge to construct proper CM	62	83.78
	CM is more interesting innovative interventional program in terms		
Advantages	1. More interaction,	54	72.97
	2. To achieve Interpersonal relationship by discussing with our colleagues and teachers.	58	78.37
	3. To bring change in our attitude towards learning new style of teaching (positive approach)	55	74.32
	4. Helpful for quick revising contents during examination**.**	65	87.84
	5. Will assist to increase score in future years by adapting CM	56	75.67
Suggestions	1. Teacher should incorporate both conventional and concept mapping for more effectiveness in teaching learning.	67	90.54
	2. Self-motivation is key player to get precise knowledge and understanding of topic	58	78.37
	3. Can be helpful in deep understanding of other preclinical subject as well and also to be implemented along with routine learning style for some topics	51	68.91

Present study proved usefulness of CM in promoting self-directed learning, correlating and retaining knowledge, and enjoyed constructing CM with full of enthusiasm and activeness. Results obtained are compatible with the findings reported by earlier researcher. [18,21,22]

By learning via CM followed by case-based learning objectives and questionnaires covered to correlate with symptoms can enhance their critical thinking abilities to conceptualize the content, are in accordance with earlier researcher. [10,18,20] Students also stated that it is helpful to achieve better performance on academic front which are supported by Rahmani A, et al. [23]

Apart from time consuming nature as disadvantage, student also felt facilitator as the key player and may affect the impact and eventually its effectiveness

Most of the students suggested incorporating CM along with traditional lecture-based approach will be become more effective teaching learning tool not for biochemistry but for other basic medical discipline as well.

When recorded advantage/s, participant mentioned its utility in fast revision, thorough understanding, arrangement of thoughts, enhanced creativity, develop critical thinking skills in correlating link between disease and biochemical aspects. However, Brockevelt & Brydl- Andrews (2011) in contrast reported CM as a growing demand rather than a significant learning tool, and 81 % of students claimed that CM did not make them learn essential concepts of the course. [24]

5. Conclusion

The cognitive domains implicated in teaching-learning are widely varied, and based on this assortment, using different resources to improve the building of information is important.

Present study indicate that participants were able to integrate clinical aspects of biochemistry by virtue of using Concept mapping as interventional strategy and assists them in correlating the clinical knowledge of biochemistry with disease symptoms. The methodology also aims to enhance critical thinking by changing linear thinking habits within their discipline to critical thinking abilities. In medical biochemistry, the use of concept mapping is not only a valuable tool for learners to retain challenging information, but also to facilitate meaningful learning that contributes to acquiring in-depth knowledge, irreparably

retaining fundamental concepts through rational thinking.

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8. Conflict of Interest

None.

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