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Comparison of Mind Mapping and Lecture Based Teaching Learning Method Among Dental Undergraduates Using Solo Taxonomy in Bangalore, India

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ABSTRACT

Aim: To compare the two educational methods Mind Mapping and lecture based methods) in teaching dental undergraduate students using the Structure of Observed Learning Outcome (SOLO) taxonomy as an assessment tool.

Materials and Methods: This cross sectional comparative study was carried out among dental undergraduates in their final year (n=45). Students were divided into lecture based learning (LBL) and mind mapping (MM) group. Three sessions were taken for both groups. The first session was followed by the MM group being taught about mind mapping, its principles, construction of mind map. LBL group after the lecture had only a group discussion. Two more sessions were taken and same procedure was repeated in both groups. At the end of 3rd lecture, all of the students had a common exam. SOLO taxonomy was used to assess the two educational methods. Scores were compared between MM and LBL groups. Student paired and unpaired t-test was used for statistical evaluation and significance level was set at $p<0.05$.

Results: Final year students (n=45, 13 males, 32 females) participated in the study. Total score in the post test among the MM was higher than LBL group (15.57+6.51 vs 8.41+2.62, p=0.001). Analysis between both the groups revealed significant differences between scores in MM and the LBL group in the various SOLO taxonomy categories, especially in the extended abstract category with the post test score mean of 4.66+1.87 in MM group and 3.6+1.22 in LBL group (p=0.001).

Conclusion: The results of the study showed that the students in MM group performed better as compared to LBL group. Mind mapping method was more effective in teaching the under graduate students. These findings suggest that integration of mind mapping in the curriculum maybe effective in promoting student's deep learning.

INTRODUCTION

Education is integral part of students' life; professional students are exposed to a large amount of information. Today's students live in tsunami of information [1].

One of the main problem a student faces during their course is organizing and retaining information. Most students develop

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many learning strategies like mnemonics, charts, maps and some may develop their own innovative methods [2]. In recent years researches have been conducted and published regarding various teaching methods like web based learning [3], didactic learning [4], and problem-based learning (PBL) [5], evidence based learning (EBL) [6] and case based learning (CBL) [7]. Though different methods differ in efficacy and applicability, they are all rooted in conceptual framework which states meaningful learning.

Lecturing is the most common teaching method in the undergraduate education in India and usage of the innovative teaching tools is still not in vogue. Lecturing relies on one way communication that mostly leaves the learners as passive participants only to take notes and probably ask questions after the lecture delivery, if and when time permits [8]. In this method, students have no opportunity to contemplate which is necessary in learning process [9]. It is very common that students often become passive recipients of the abundant information and are rarely involved in learning process [10].

The traditional lecture based teaching method, is doubtful to be efficient enough and memory retention by this method after 6 months is less than 5 percent [11].

So, it is important to revise traditional methods of teaching and take advantage of new, active and student-centered educational methods [8]. When comparing with other approaches for learning it is always seen that lecture based method of learning always falls short.

Ilgüy et al. in 2014 compared the impact of case-based learning (CBL) and lecture-based learning (LBL) on fourth-year dental students' clinical decision making by using the Structure of Observed Learning Outcome (SOLO) taxonomy. And found that Students who were taught with CBL had higher scores at the top two levels of the SOLO taxonomy than students taught with LBL [7].

Smitts et al. investigated the effectiveness of problem-based learning (PBL) in comparison with lecture-based learning in a postgraduate medical training program concerning the management of mental health problems for occupational health physicians. The problem-based program appeared to be more effective than the lecture-based program in improving performance. But both were equally effective in improving knowledge levels [12].

Sangestani and Khatiban in their study concluded that PBL improved application of theory lesson in clinical practice, increased learning motivation and enhanced educational activity in class. There was more satisfaction with PBL method. Hence should be applied more in undergraduate courses [13].

Roya Sadeghi et al. conducted a study to compare the students' learning and satisfaction in combination of lecture and e-learning with conventional lecture methods. E learning is effective in increasing the students' learning rate than LBL method. Concluded that using e-learning could be used as a supplement to traditional teaching methods or sometimes as educational alternative method because this method of teaching increases the students' knowledge, satisfaction and attention [14].

To overcome this limitation of lecture based method and achieve active learning, a new strategy called 'Mind mapping' was introduced by Tony Peter Buzan and Dr. Allan Collins. MM is a multisensory tool that uses visuospatial orientation to integrate information, and consequently, help students organize and retain information. Using graphic ideas and more images produces more precise and powerful associations of the ideas.

A mind map is a schematic representation of words, ideas, concepts or other items associated with a theme of study, being composed of topics organized into a hierarchy; i.e. there is a central topic from which others radiate **(Figure 1)**.

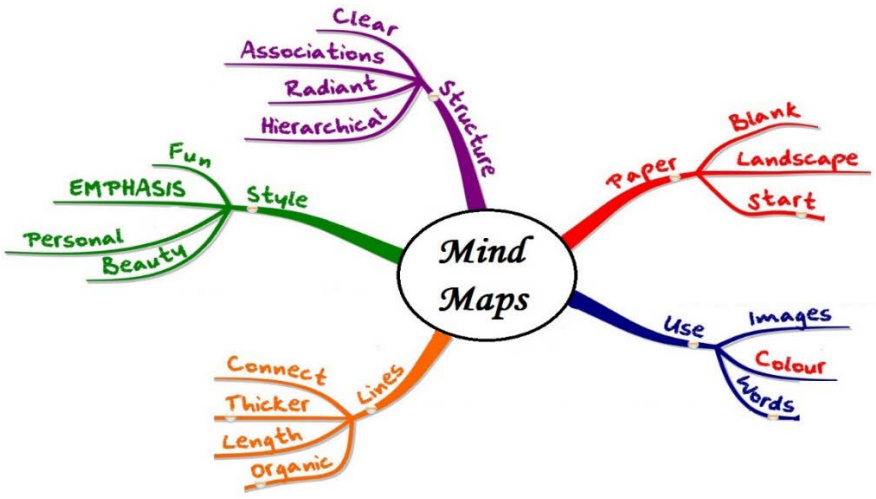

Figure 1. Schematic representation of mind map.

Its construction is very simple. In a mind map the main theme of the study is inserted in the center, from which keywords connected by colored lines and images branch nonlinearly in a divergent pattern. These keywords correspond to subtopics that, in turn, may present smaller branches that present more detail about the subject included, in a progressive branching pattern.

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Thus, a mind map is mainly a tool for organizing ideas via keywords, colors and images in a structure that radiates from a center **(Figure 2)**.

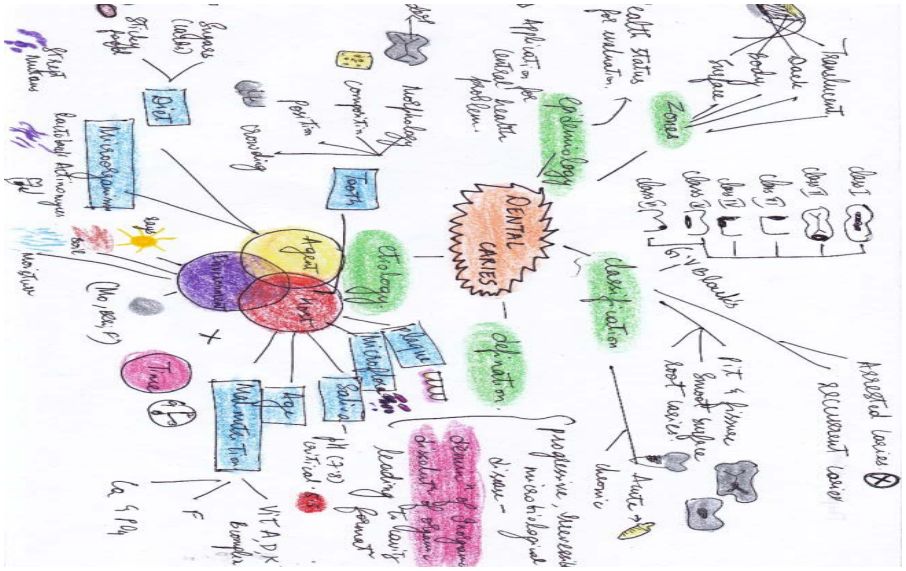

Figure 2. A Mind Map of "epidemiology of dental caries created by the MM group students using essential features of a good mind map - Epidemiology of dental caries - mind map.

Unfortunately, this technique has received little attention since its invention. But in recent years, there has been a growing number of publications on learning strategies used in medical education, which can help students to learn and integrate information.

The Structure of Observed Learning Outcome (SOLO) taxonomy, developed by Biggs and Collis, 2 is a way of evaluating students' responses and describes level of increasing complexity in students understanding of a topic. This model has five levels of understanding.

1. Prestructural – here the answer misses the point
2. Unistructural – here the answer shows one string of relevant details
3. Multistructural – in this the answer contains several strings of details that are unrelated to each other
4. Relational- the answer shows how the different strings of details relate to each other
5. Extended abstract- the answer shows that there is construction of knowledge and there is higher level of abstraction **(Figure 3)**.

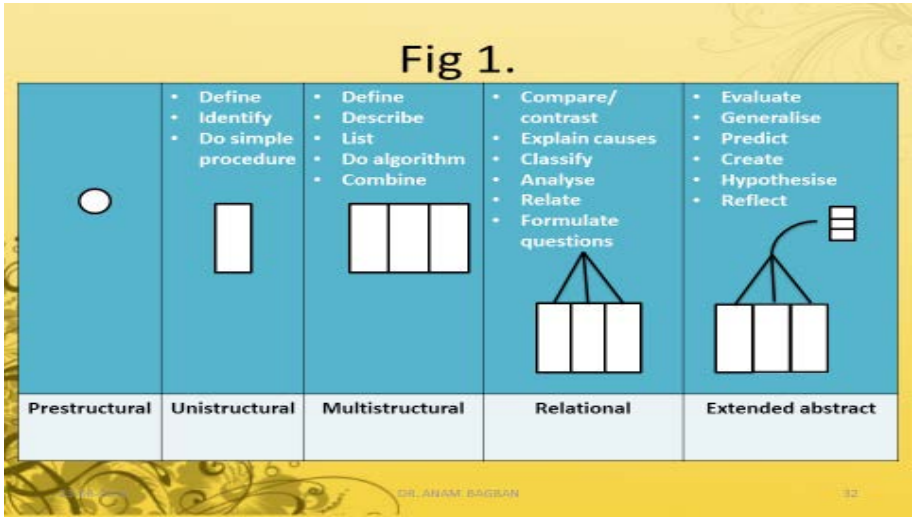

Figure 3. Subgroups of SOLO Taxonomy.

By this mean we can classify the learning outcome in terms of their complexity, enabling us to assess students work in terms of quality.

Various studies are published comparing lecture based learning method with different approaches of learning (CBL, PBL, EBL, E-learning) but only some studies compared lecture based learning with mind mapping.

Hence the present study was conducted with the objective to compare the two educational methods (MM and lecture based methods) in teaching the dental undergraduate students and assess their complexity of learning by using SOLO taxonomy.

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MATERIALS AND METHODS

Study Design and setting

A cross sectional comparative study was carried out study in the department of public health dentistry of KLE's Institute of Dental sciences, Bangalore.

All final year undergraduates (n=45), studying in the academic year 2015-2016 of K.L.E society's institute of dental sciences, were selected using convenience sampling. The study was carried out for duration of one month (august 2015).

Ethical approval was granted by the institutional review board of the KLE's Institute of Dental sciences, Bangalore.

Inclusion Criteria

» Final year dental undergraduate students

» Willing to voluntarily participate in the study were considered.

Study procedure

A 45-minute session was taken on the topic 'pit and fissure sealants' for the entire class. Immediately after the lecture a test was conducted. The questions were based the hierarchy of SOLO taxonomy. No prior intimation was given about the test. Assessment was done via a pre-prepared answer sheet by an expert panel **(Table 1)**.

Table 1. Three lectures spaced one week apart were undertaken for both the groups.

Session	MM Group	LBL Group
Baseline	Students were introduced to MM principles in a 45-minute session. Topics considered in this stage includes meaningful learning, mind map introduction and the instruction of constructing, assessing and scoring of mind maps [3]	No baseline session
1st session	Mechanisms of action of fluoride: Afterward the group were asked to draw a mind map, using key concepts that were introduced to them. A facilitator helped them.	45-minute session and a group discussion. An equal time frame was allocated to each student to discuss.
2nd session	Epidemiology of dental caries: Group drew mind map with the help of facilitator.	45-minute session and Group discussion
3rd session	Atraumatic restorative treatment: Group drew mind map with the help of facilitator.	45-minute session and Group discussion

Then all the 45 students of final year BDS were included in the further study. Study was explained and written informed consent was taken from all the students to be part of the study (Annexure 1).

By simple random method (lottery method), participants were divided into two groups i.e., LBL and MM groups. There were 23 students in LBL group and 22 students in MM group.

At the beginning of the study the students allocated to MM group were asked for their familiarity with mind mapping. None of them were familiar with this strategy **(Table 1)**.

Group 2 – lecture based learning group (LBL)

Students who had been assigned to these groups:

Assessment

Immediately after the 3rd session, students in both groups attended a common test of 50 mark total, on the three topics taught.

The questions were based according to the categories of SOLO taxonomy to assess the retention and retrieval of information taught to them.

The difficulty level of each question was determined based on SOLO Taxonomy's five categories, from less to more complex **(Figure 3).**

No prior intimation was given about this test and the students had to fill their responses on the spot and answer sheets were collected back immediately. A pre-prepared answer sheet, which was conducted via an expert panel, was used for scoring of the answers. Before the exam, the facilitator provided information to both the groups about how the responses would be scored at each level.

e-ISSN:2320-7949
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In pre structural (A) (5 questions -1 mark each) were asked identify a condition, name the microorganism responsible for dental caries, who introduced ART etc. In unistructural (B) (2 questions - 2.5 marks each) both the groups were asked to define dental caries and epidemiology. Likewise increasing in complexity in multistructural (C) (3 questions- 5 marks each) questions were to list the host factors responsible for dental caries, list the mechanism of actions of fluoride and draw Keyes triad. In relational (D) (2 questions- 5 marks each) category to assess whether the students could relate different string of details, the questions were about to explain the environmental factors of dental caries and to explain any two mechanism of action of fluoride. Finally, to see if the student can construct new knowledge and whether can generalize to higher level of abstraction, the questions constructed in extended abstract (E) (3 questions- 5 marks each) category were to describe the socioeconomic status effect influencing dental caries, predict the dental caries pattern in people if high amount of sugar is consumed and as a dentist how would you help the people from different socioeconomic status **(Table 2)**.

Table 2. Questions according to SOLO taxonomy categories.

Category **Total score: 50**	**Questions**				
Pre-structural – [A] (1 mark each)		Who introduced ART	Name the microorganism responsible for initiation of pit and fissure caries	 Identify this factor causing dental caries	  Which mechanism is this
Uni-structural [B] (5 marks)	Define dental caries and epidemiology				
Multi-structural [C] (5 marks each)	Draw Keyes triad	List the host factors causing dental caries	List the mechanisms of action of fluoride		
Relational [D] (5 marks each)	Explain any two mechanism of action of fluoride Explain the environmental factors for dental caries				
Extended abstract [E] (5 marks each)	How does socioeconomic status factor influence dental caries?	Predict what happens if amount of sugar taken is high.	As a dentist how do you help the people from different socioeconomic status.		

Statistical Analysis

Statistical Analysis was done using SPSS version 22. Quantitative data were evaluated using independent t tests in order to compare the two groups. And paired t test was used for within group analysis between the categories of SOLO taxonomy. Significant level was considered as p-value ≤0.05.

RESULTS

A total of 45 students (13 males, 32 females) participated in the study. All eligible students participated with only one drop out in MM group (did not attend 3rd session).

Sum of the test scores was considered as total score. Comparison of the pre and post-test mean scores in two groups of MM and LBL groups using paired t test was done **(Table 3)**. MM group and LBL group performed similar in the pre-test with the mean of 4.92+1.02 in MM group and 4.91+1.85 in the LBL group. In the post test the both MM and LBL groups performed better compared to the pre-test but MM group had a mean almost double of the LBL group 15.57+6.51 vs 8.41+2.62. There was statistically significant difference in the pre and post test scores of both groups with the p value of 0.001 (paired t-test).

Table 3. Comparison of pre and post test scores in two groups of MM and LBL.

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Groups	Test score	N	Mean ± std deviation	t value	P
MM Group	Pre test	22	4.92 ± 1.02	7.690	0.001*
	Post test	21+	15.57 ± 6.51		
LBL Group	Pre test	23	4.91 ± 1.85	5.689	0.001*
	Post test	23	8.41 ± 2.62		
+ 1 drop out, * significant at p<0.05 (Paired t test)					
LBL: Lecture based learning, MM: mind mapping					

Mean Scores of pre-test and post-test according to the SOLO taxonomy categories were analysed using paired t test in LBL and MM group **(Tables 4 and 5)**.

Table 4. Mean values of pre and post test scores of SOLO Taxonomy categories according to lecture based teaching method.

SOLO category	LBL Pre test scores	LBL Post test scores	t value	p value
Pre-structural (A)	0.63 ± .52	1.17 ± 1.04	2.885	0.009*
Uni-structural (B)	0.47 ± 0.46	1.23 ± 0.49	10.96	0.001*
Multi-structural (C)	0.93 ± 0.82	1.58 ± 1.42	3.961	0.001*
Relational (D)	0.69 ± 0.66	1.54 ± 1.26	4.092	0.001*
Extended abstract (E)	2.15 ± 1.01	3.6 ± 1.22	4.360	0.001*
*Significant at p<0.05 (Paired t test)				
LBL: Lecture Based Learning				

Table 5. Mean values of pre and post test scores of SOLO Taxonomy categories according to Mind Mapping teaching method.

SOLO category	MM pre test scores	MM post test scores	t value	p- value
Pre-structural (A)	0.69 ± 0.51	2.21 ± 1.17	5.775	*0.001
Uni-structural (B)	0.52 ± 0.46	1.52 ± 0.62	6.325	*0.001
Multi-structural (C)	0.78 ± 0.64	4.11 ± 2.01	7.338	*0.001
Relational (D)	0.97 ± 0.66	3.69 ± 2.14	5.971	*0.001
Extended abstract (E)	1.95 ± 0.65	4.66 ± 1.87	6.151	*0.001

Table 4 shows the mean values of SOLO categories according to LBL teaching method. Statistically significant differences were found between the means of all the SOLO taxonomy categories in the LBL groups (p<0.05). With the highest mean seen in the category E i.e., 3.6+1.22 in the post test group.

Students taught with MM strategy had highest scores in C, D and E category with the means of 4.119+2.0119, 3.690+2.1475 and 4.667+1.8797 in the post test respectively as shown in Table 3. Statistically significant difference was seen in all categories of the MM group (p<0.05).

Scores were also compared between the different categories of SOLO taxonomy in the pre-test and post-test between MM group and LBL group using Independent t test **(Tables 6 and 7)**.

Table 6. Comparison of the mean values of SOLO taxonomy categories between the pre-test scores in both groups.

Groups	n	Mean ± Std. Deviation	t value	p value
LBL - MM pre-test Prestructural (A)	45	0.63 ± 0.52	0.383	0.704
LBL - MM pre-test Unistructural (B)	45	0.47 ± 0.46	0.326	0.746
LBL - MM pre-test Multistructural (C)	45	0.93 ± 0.82	0.661	0.512
LBL - MM pre-test Relational (D)	45	0.69 ± 0.66	1.396	0.170
LBL - MM pre-test Extended Abstract (E)	45	2.15 ± 1.01	0.768	0.447
*Significant at p<0.05 (Independent t test) LBL: Lecture Based Learning, MM: Mind Mapping				

Table 6 shows the comparison of the mean values of SOLO taxonomy categories between the pre-test scores in both LBL and MM groups by Independent t-test. No significant differences were seen. With the highest mean in the category E, 2.15+1.01 (p=0.447).

Table 7. Comparison of the mean values of SOLO taxonomy categories between the post-test scores in both groups.

Groups	n	Mean ± Std. Deviation	t value	p value
LBL - MM post-test Prestructural (A)	44	1.17 ± 1.04	3.110	*0.003
LBL - MM post-test Unistructural (B)	44	1.23 ± 0.49	1.684	0.100

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LBL - MM post-test Multistructural (C)	44	1.58 ± 1.42	4.848	*0.001
LBL - MM post-test Relational (D)	44	1.54 ± 1.26	4.080	*0.001
LBL - MM post-test Extended Abstract (E)	44	3.60 ± 1.22	2.231	*0.031
*Significant at p<0.05 (Independent t test) LBL: Lecture Based Learning, MM: Mind Mapping				

Whereas the comparison of the mean values of SOLO taxonomy categories between the post test scores in both LBL and MM groups by the independent t test in the Table 5 shows statistical significant differences in the category A, C, D, E with the mean 1.17+1.04, 1.58+1.42, 1.54+1.26 and 3.60+1.22 respectively with p value less than 0.05. Only category B didn't show any statistical significant difference with a mean of 1.23+0.49.

The extended abstract (E) had the highest scores with mean values 3.60+1.22, while the lowest scores were seen in the pre structural (A) 1.17+1.04.

DISCUSSION

Evaluation of the quality of education provided in dental schools requires assessment of existing curricula. Evaluating learning outcomes and retention of information is an integral part of education and directly affects the ability of the students [7]. Higher education in health sciences in general, and in medical studies has been the target of severe criticism [10].

Different teaching styles exist, each with their own unique sets of strengths and weaknesses. But in dental undergraduate education, an unfortunate number of teachers utilize lecture-based learning as the ultimate classroom strategy. While it undeniably boasts a few valuable advantages — most notably fortified note-taking and memorization skills, the approach isn't exactly ideal for all situations and students.

In this study we compared two educational methods in teaching the final year undergraduate students the traditional lecture based method and the newer powerful tool to teach new knowledge mind mapping.

The results of the study showed that mind mapping method was more effective as a teaching and learning method than the lecture based method.

We found that the mean score of students in the MM groups was significantly higher than the LBL groups (post-test -15.57+6.51 vs 8.41+2.62, p=0.001). The findings are similar to the study conducted by Saeidifard et al. [15] and by Wikramasinghe et al. [16] where they found that Concept mapping method was more successful than lecture-based method and Mind map technique was perceived as a useful learning tool respectively.

The questions that were selected were based on the 3 lectures taught to them, over a period of three weeks. The questions were selected to encourage students to recall and retrieve the previous sessions lectures. Students enjoy mind maps, are more focused to draw the information they learnt into a map and think that it helps them learn better.

The vast majority of studies have indicated the important role of MM in development of meaningful learning and problem solving. They indicate that through mind mapping students could integrate basic and clinical knowledge and move from linear thinking patterns to more integrated holistic patterns.

In our study both the groups performed similarly in the pre-test. After the introduction of mind mapping strategy and in the span of three weeks the students in the MM group could perform much better compared to the LBL group as seen by the means of post test scores. The findings are similar to the study by D'Antoni et al. [17] where they found that brief introduction to mind mapping allowed novice MM subjects to perform similarly to the traditional short note taking subjects. This demonstrates that medical students using mind maps can successfully retrieve information in the short term, and does not put them at a disadvantage compared to SNT students.

The SOLO taxonomy is based on evaluation of learning outcomes. Lucander et al. [18] reported that it was a Useful tool for developing and assessing deep learning in dentistry. In our study, the use of the SOLO taxonomy to analyse students learning did not yield any significant difference in both the groups as evident by the pre-test scores. After the three educational sessions the scores improved in both MM and LBL groups. The (C) and (E) categories of MM group were higher than the LBL group i.e., the students performed better in not only in the multistructural but as well as extended abstract category which indicates reflecting and hypothesizing of the ideas. As mind maps are graphic ideas, students get involved in creating mind maps using different colors, shapes, designs for the subtopics. This may act as an effective method for generating ideas by association. This suggests that by using mind map strategy one can improve the deep learning by the students.

We found the the highest scores were seen in category E in both the groups compared to other SOLO taxonomy categories. This is in contrast to study conducted by Ilguy et al. [7] in 2014, where the highest scores were obtained in category A compared to other categories.

Deeper learning is essential for retention of information. MM facilitates the development of reflective thinking and deeper

understanding, helps learners to focus on a topic and solve a difficult topic in fun creative way. More effort should be spent to support a deep approach to learning compared to the traditional education strategies, especially here in India where lecture based teaching method predominates. So as both the teacher and the student have a better understanding of the subject and outdo in the knowledge gained by this innovative teaching and learning method.

LIMITATIONS

Study group consisted of a small number of subjects enrolled from one dental college. So should be careful in generalizing the results.

In the MM group, the facilitator helped students draw maps and also motivated them to learn mind maps followed by discussion. Whereas in LBL group there was just discussion and clearing the doubts the students may have. The second mentioned role of the teacher might have affected our result.

CONCLUSION

This study demonstrates that mind mapping can be easily learnt and as well can be easily taught to undergraduate students who have no previous background in mind mapping and doing so requires no cost or expensive equipment. It can be suggested that the use of mind maps as an aid in dental undergraduate education is a potentially valid tool that can be used by students and teachers for multiple purposes.

Thus, mind mapping may be an attractive resource to add to the study strategy repertoire of dental undergraduate students to help them learn, organize information and retrieve it when it is needed.

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