Effectiveness of mind mapping as compared to didactic lectures for teaching anatomy among first-year medical students - A randomized control study

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SUMMARY

Several methods have been suggested to encourage greater student participation during lectures. Mind mapping is a learning tool that uses pictorial representations of concepts and their relationships. The objectives of this study were to compare the knowledge acquisition in anatomy and perceptions between didactic lectures and mind mapping among first year students at a medical college in India. First year undergraduate medical students (n=60 in one batch and n=149 in the next batch) were randomly divided into two groups which received either the mind-mapping intervention or a didactic lecture. Eight topics were covered in such a manner. After each topic, the groups crossed over and received the alternate intervention. Each intervention was followed by a ten-item single-best-response multiple-choice knowledge test. The perceptions of students were obtained using a questionnaire which had both quantitative and qualitative components. The data were summarized using means and standard deviations. Group differences were estimated using the independent sample T test. The mean scores on the multiple-choice-questions (MCQ) test were significantly higher after mind-mapping compared to didactic lectures in seven out of eight sessions. The perceptions of the students about mind mapping were largely positive, especially in relation to integration and interest. One drawback mentioned about the mind-mapping method was that it was relatively time-consuming. Mind mapping resulted in significantly greater knowledge acquisition as compared to didactic lectures, and was well received by the students. It has the potential to be used more widely in anatomy education.

Key words: Mind mapping – Didactic lectures – Medical students – Anatomy

INTRODUCTION

The first-year curriculum for undergraduate students in medical colleges in India includes the subjects of anatomy, physiology, and bio-

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chemistry. Nearly half of the curricular time is devoted to anatomy (RGUHS, 2019). A wide variety of teaching and learning methods are employed for anatomy instruction, which includes 220 hours devoted to lectures (RGUHS, 2019). The challenges faced by students while learning anatomy include difficulties in the visualization of structures, the vast and often abstract nature of the information and the limited time available (Cheung et al., 2021a). Additionally, the approaches and resources utilized by students to learn anatomy are likely to influence the acquisition of the desired learning outcomes (Cheung et al., 2021b; Patera, 2021). There have been many attempts to modernize the teaching and learning of anatomy to make it more clinically relevant and participatory while simultaneously adapting to a decrease in the available time due to an ever-expanding curriculum (Ahmad et al., 2021; Bay and Ling, 2007; Johnson et al., 2012; Miller et al., 2002; Sugand et al., 2010).

Didactic lectures have been part of anatomy education in medical schools for many years (Sugand et al., 2010). Lectures have the potential for an efficient and effective method to convey information to students (Luscombe and Montgomery, 2016). A major drawback of the didactic lecture is its tendency to become a passive and monotonous monologue (Najmi, 1999). Several guidelines and strategies have been proposed to improve the learning outcomes from lectures (Leonardi, 2007; Regula, 2020; Richardson, 2008; Zakrajsek, 2018). Previous studies have shown that well-conducted lectures have a positive impact on student perceptions and knowledge gain (Demir et al., 2017; Reed et al., 2008; Zinski et al., 2017). There have been many attempts to transform potentially boring and content-heavy didactic lectures into active learning sessions by introducing meaningful activities during the lecture (Chimmalgi, 2019; Morton and Colbert-Getz, 2017; Shankar and Roopa, 2009).

Mind maps are pictorial representations of concepts and their relationships (D'Antoni et al., 2010). Buzan formally defined mind maps and introduced them to the world in the 1970s' (Buzan, 2018). The three essential features of a mind map are a central image, thick branches radiating from the central image and a single keyword or image placed on each branch (Buzan, 2018). Secondary and tertiary branches can then be added as the mind map develops (Buzan, 2018). Mind maps differ from concept maps in being more visual and less complex (Eppler, 2006). The utility of mapping techniques has been explained using the constructivist learning theory. Learners must initially use their pre-existing knowledge and sequentially build on it as they construct mind maps. Linkages between different images and keywords help to create integration networks within the brain for better retrieval and application of information. This enables deep learning as opposed to superficial rote learning (Pudelko et al., 2012). Mind maps have been used to facilitate learning in diverse settings (Amrita et al., 2017; Budd, 2004; Edwards and Cooper, 2010; Farrand et al., 2002; Kalyanasundaram et al., 2017; Merchie and Van Keer, 2012; Samsudin and Irwanto, 2021; Tungprapa, 2015). A meta-analysis of 52 studies conducted in 2014 suggests that the use of mind mapping improves academic achievement (Zhao, 2014). Mind maps have also shown to be helpful in teaching and learning anatomy (Abdolahi et al., 2011; Deshatty and Mokashi, 2013; Ghanbari et al., 2010; Ren and Jiang, 2019; Teli et al., 2020).

Traditional lectures are usually didactic, reinforcing the passive learning patterns to which students are used. There is a pressing need to transform the traditional lecture setting from a passive into a more active one. In the present study, mind mapping was introduced in the lecture setting to try and make learning more active and effective. It was hypothesized that the use of mind maps in lecture settings would improve knowledge acquisition compared to traditional lectures. The research objectives of the study were the following: 1) to compare the scores on an immediate post-session multiple-choice-question (MCQ) test obtained by 1st-year undergraduate medical students taught anatomy by traditional lectures or mind mapping; 2) to assess the perceptions of these students about the mind mapping method of learning and the traditional lecture.

MATERIAL AND METHODS

Study design and population

Approval from the institutional ethics committee was obtained prior to the study. All students who enrolled for the undergraduate medical course in the years 2015 and 2016 were included in the study. The number of students in the batches of 2015-16 and 2016-17 were 60 and 149 respectively. A universal sampling strategy was employed. Written informed consent to participate in the study was taken from the students.

This was a randomized-control cross-over study (Fig. 1). The students of each batch were randomized into two groups using an online random number generator. One of the investigators (SM) conducted all the mind-mapping sessions, while another investigator (SD) took all the didactic lectures. The lectures were selected based on the mutual convenience of the investigators. To ensure standardization of the content, the specific learning objectives of each session were defined in advance. Students allotted to the mind-map group (MMG) were taken to a classroom and administered the intervention by SM, which will be described in more detail later. Concurrently, the students in the didactic lecture group (DLG) were taken to another classroom and taught using a didactic lecture by SD. The groups crossed over after each session (Fig. 1). A total of eight topics were thus covered (Fig. 1). All the sessions were of a duration of one hour. The sessions were scheduled to ensure that there was at least a two-week gap between successive sessions.

The interventions

The schedule for the anatomy classes was made available to the students at least two weeks in advance. The dissections of the relevant regions were completed prior to the interventions to enable better comprehension. There were no specific instructions provided to the students regarding prior preparation before either intervention.

An introductory session on mind maps was taken by an SM for the entire batch of students before the actual intervention. During this session, the students were introduced to the concept of mind maps and to guidelines for their creation. These guidelines included those related to style, clarity, keywords, and visual elements (Fig. 2). For the mind-mapping session, the students were divided into groups of six. The students in each group were made to sit around in a circle. The mind-mapping session for the MMG started with

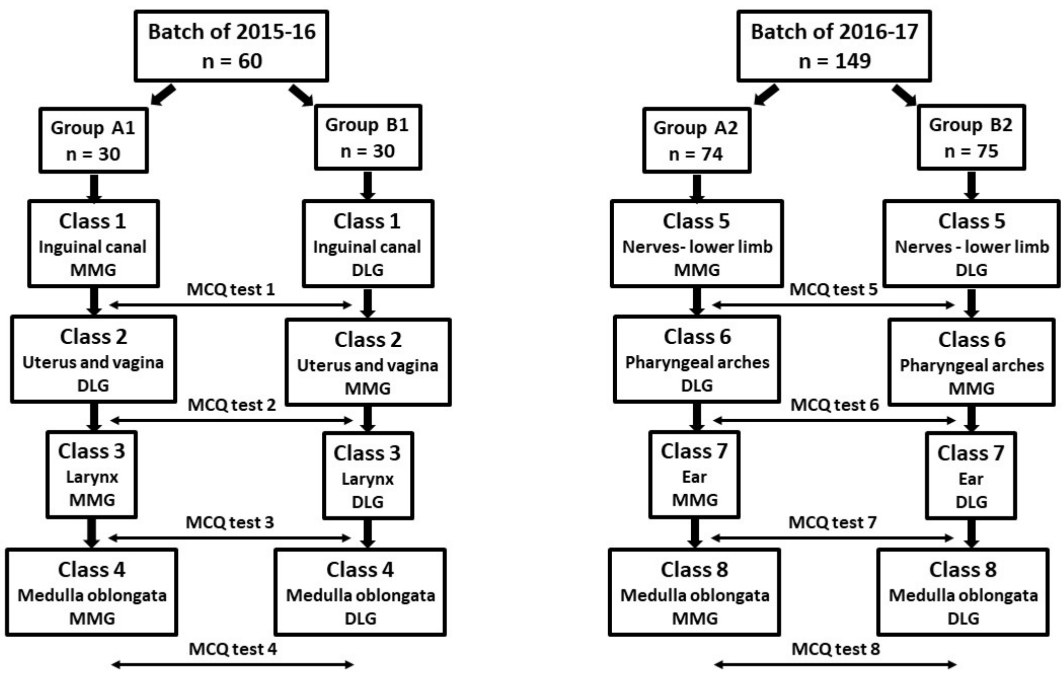

Fig. 1.- A schematic representation of the study design.

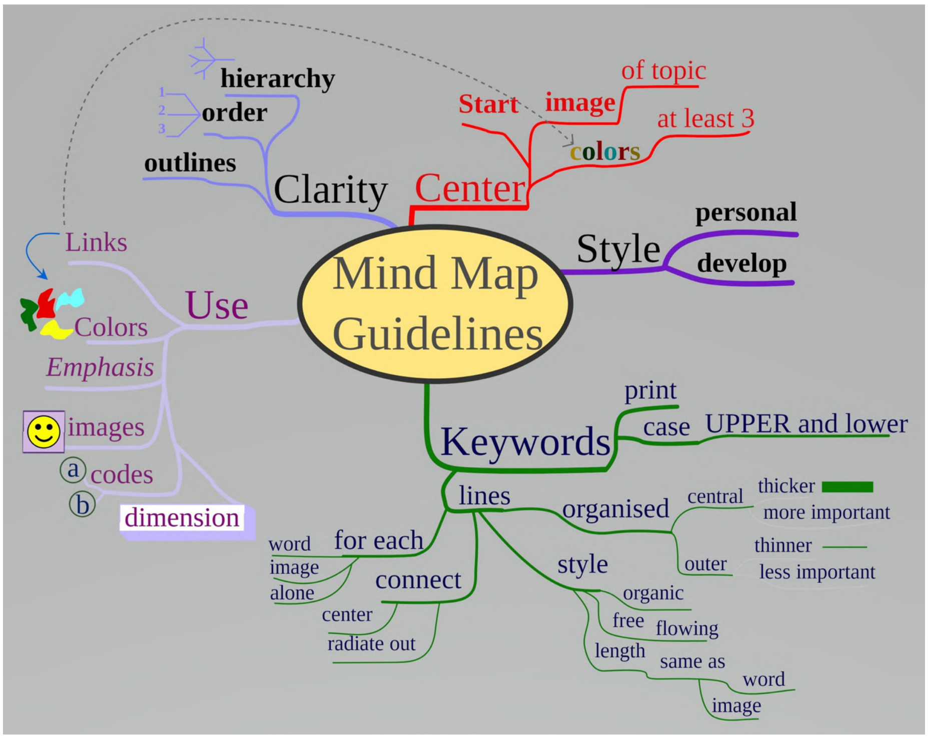

Fig. 2.- The mind map that was used as an example to demonstrate the guidelines for their creation (from Nicoguaro, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0).

listing of the specific learning objectives for the topic by the teacher. It is important to note that the teacher did not explain the topic during the mind-mapping session. As mind map is a visual tool that encourages creative thinking and collaboration among students; we wanted to give the students the opportunity to explore the topic on their own. Each group was then asked to create mind maps on chart paper that was provided to them (Fig. 3). The students were free to refer to available resources such as textbooks and online resources. This exercise was conducted for half an hour. The next 20 minutes were spent discussing the mind maps and clarifying any doubts that the students had. The teacher's input on the topic was restricted to clarifying any doubts that the students had during the time allotted for discussion of the mind maps. The session ended with the administration of a 10-item MCQ test as described below.

The DLG simultaneously received a one-hour didactic lecture session on the same topic, followed by the administration of the MCQ test. The didactic lecture was taken using PowerPoint slides and a blackboard. The specific learning objectives were explicitly stated at the beginning of the didactic lectures as well. As an example, the specific learning objectives for the class on the major nerves of the lower limb are mentioned below.

Describe the femoral, obturator, sciatic, tibial, and common peroneal nerves under the following headings:

Origin

Root value

Course with important relations

Distribution with important branches

Termination

Applied aspects

The outcomes

At the end of each session, students in both groups were administered a 10-item MCQ test. Each item was of the single-best response type and contained four options. The MCQs' were based on the defined specific learning objectives for each session. The test items contained both factual and application-based questions. The first author created the MCQs based on best-practice guidelines, following which they were scrutinized by the other authors for any technical flaws or errors before administration to the students (Boland et

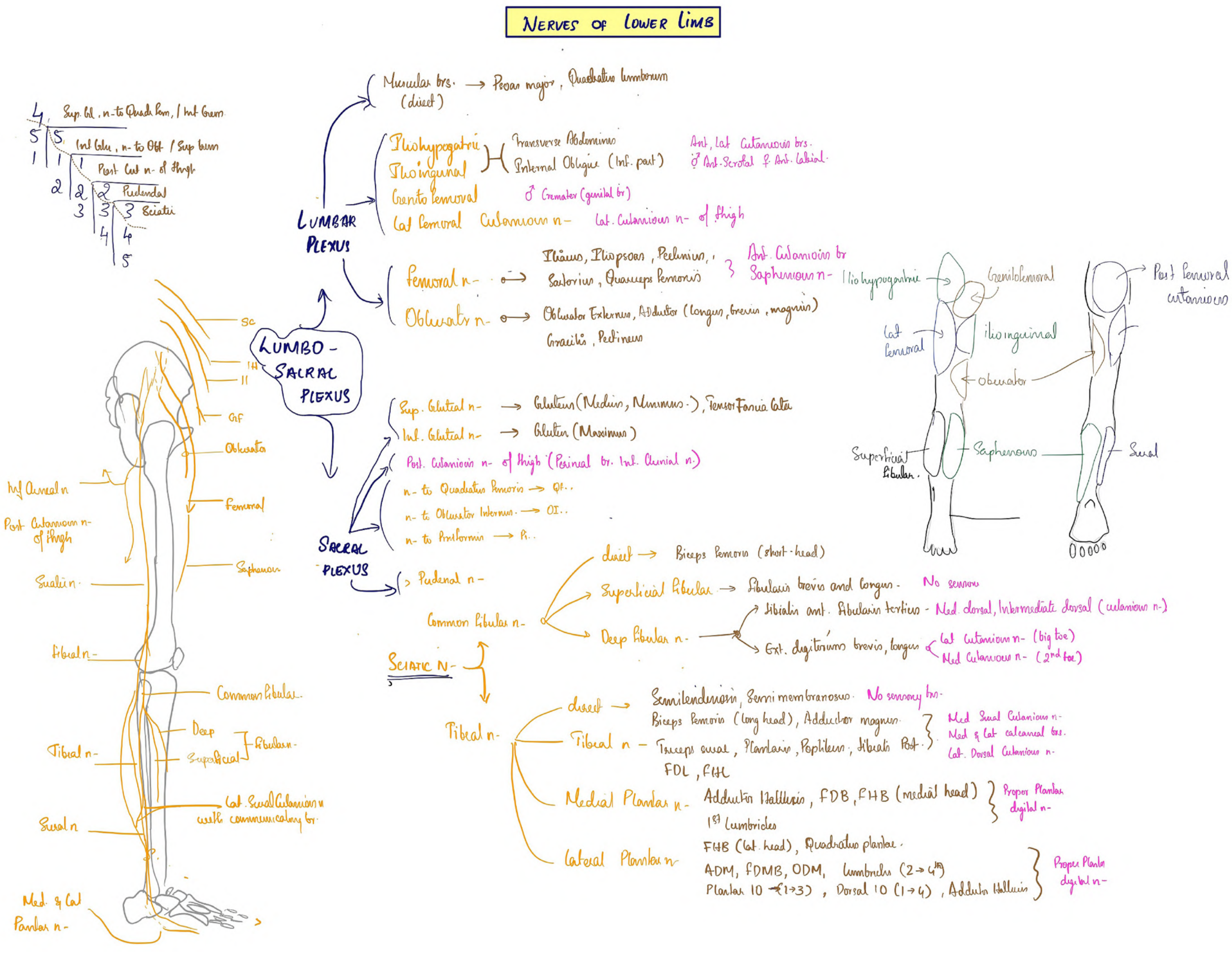

Fig. 3.- An example of a mind-map developed by a group of students for the class on the nerves of the lower limb.

al., 2010). The perceptions of the students about mind-mapping compared to traditional lectures were obtained using a questionnaire designed for the purpose (Table 2). The questionnaire contained 10 statements and two open-ended questions. The statements had to be responded to using a five-point Likert scale with higher scores indicating more favorable perceptions towards mind-mapping. The open-ended questions in the questionnaire were “What were the aspects of the mind mapping sessions that you enjoyed or benefitted from?” and “What were the aspects of the mind mapping sessions that you did not enjoy or benefit from?”.

Statistical analysis

The mean and standard deviation of the test scores and questionnaire item scores were calculated. Group differences were estimated using the independent sample T test. A P value of less than 0.05 was considered statistically significant. Version 16 of SPSS was used for statistical analysis. A thematic analysis was performed on responses to the open-ended questions in the questionnaire.

RESULTS

Table 1 shows the mean scores obtained by the two groups for the eight sessions. The mean scores obtained by the MMG were higher for all the eight sessions and significantly so for seven sessions. The responses to the statements in the perception questionnaire are summarized in Table 2. The mean scores for the items in the questionnaire suggest that students were overall positive about the role of mind mapping in facilitating learning as compared to lectures. The students felt that mind-mapping sessions were more interesting and helped them better integrate content. However, they were more equivocal about the perceived role of mind mapping in learning concepts and aiding exam preparation.

Table 1. Comparison of the mean MCQ test scores between the two groups.

CLASS OF 2015-16	MMG[a]	DLG[b]	P value
Lecture 1	n = 30 8.50 ± 0.95	n = 30 8.03 ± 0.9	0.07
Lecture 2	n = 27 8.60 ± 0.62	n = 30 8.04 ± 0.94	0.01*
Lecture 3	n = 29 8.68 ± 0.06	n = 30 7.86 ± 0.73	0.001*
Lecture 4	n = 29 8.72 ± 0.59	n = 29 8.06 ± 0.7	0.001*
CLASS OF 2016- 17	**MMG[a]**	**DLG[b]**	**P value**
Lecture 5	n = 71 8.23 ± 1.24	n = 71 7.75 ± 1.05	0.01*
Lecture 6	n = 70 8.43 ± 1.17	n = 71 7.97 ± 0.91	0.01*
Lecture 7	n = 72 8.24 ± 1.00	n = 72 7.86 ± 0.88	0.02*
Lecture 8	n = 70 8.19 ± 1.11	n = 72 7.83 ± 0.86	0.04*

n is the number of students who were present for each class; aMMG – mind-map group; bDLG – didactic lecture group; * indicates those results that were significant ($P<0.05$)

Table 2. Mean item scores on the perception questionnaire (n = 170).*

Sl. No.	Item	Mean ± SD
1.	Mind mapping helps me to recall facts better than lectures	3.29 ± 0.2
2.	Mind mapping helps in learning concepts better than traditional lectures	3.12 ± 0.1
3.	Mind mapping is more interesting than lectures	3.6 ± 0.9
4.	Mind mapping helps me to integrate information better than a lecture	3.6 ± 0.7
5.	Mind mapping helps me to prepare for the exams better than lectures	3.04 ± 0.1
6.	Mind mapping helps me to retain information longer than lectures	3.4 ± 0.1
7.	Mind mapping helps me to apply the information that I learn better than lectures	3.3 ± 0.1
8.	The mind mapping session can replace lectures	3.5 ± 1.2
9.	Mind mapping should continue for future batches	3.4 ± 1.1
10.	I would be willing to participate in more mind-mapping sessions	3.3 ± 1.0

*Likert scale: 1 - Strongly disagree; 2 - Disagree; 3 - Not sure; 4 - Agree; 5 - Strongly Agree

The responses to the open-ended questions revealed that students enjoyed the creativity and visual elements required in constructing mind maps. They also mentioned that mind maps helped to classify and consolidate information in a manner which helped them retain it and facilitate future revision. The other aspects appreciated by the students were the interactive nature and novelty of the mind map sessions. The most important drawback of the mind map sessions perceived by the students was the limited time that was available. Some of them felt that creating mind maps was complicated and therefore required more help from the teacher. The need for prior preparation before a mind map session was stated as one of its disadvantages. Inadequate coverage of topics during mind-mapping sessions was another concern of the students.

DISCUSSION

The results of the present study suggest that the creation of mind maps by students is at least as effective as didactic lectures for achieving learning outcomes in anatomy. Previous studies have shown that incorporating mind mapping as a study strategy improves learning (Amrita et al., 2017; D'Antoni AV et al., 2010; Deshatty and Mokashi, 2013; Farrand et al., 2002; Kalyanasundaram et al., 2017; Ying et al., 2017) Mind maps have also been successfully used to reinforce learning (Ashakiran et al., 2012). The use of mind maps by teachers during a lecture to present content appears to facilitate learning (Abdolahi et al., 2011; Duffy et al., 2015; Ghanbari et al., 2010; Johnson, 2014; Teli et al., 2020). In the current study, students in the MMG had to actively construct mind maps in the classroom as part of the intervention. A study in which students had to draw maps along with the teacher during histology lecture classes showed a significant improvement in the examination results as compared to the previous years (Kotzé and Mole, 2015). This method could be added to the ever-growing list active learning methods that can be used in the classroom to facilitate learning. This is especially pertinent in the Indian context where a competency-based curriculum has been introduced for undergraduate medical education in 2019 (Medical Council of India, 2019). One of the endeavors of this curriculum is to replace didactic teaching methods with active learning methods.

The positive perceptions of the students about mind mapping in this study are similar to other studies (Amrita et al., 2017; Ashakiran et al., 2012; Deshatty and Mokashi, 2013; Kalyanasundaram et al., 2017; Ren and Jiang, 2019; Teli et al., 2020). An important insight gained from this study is that adequate time needs to be given to students if mind maps are used in a lecture setting. This aspect has been also mentioned in previous studies where mapping has been used as a learning strategy (Pudelko et al., 2012). It is likely that the perception of inadequate coverage was because students were accustomed to attending didactic lectures in which the teacher acted as a knowledge provider. On the other hand, the mind map intervention in this study involved a more active, non-linear approach to learning which might have given rise to this perception (Petersen et al., 2020). The need for prior preparation was probably felt more acutely by the MMG, as this would have facilitated more meaningful group discussions and improvement in the quality of mind maps. However, this was not the case in the didactic lecture, where the content was provided by the teacher. A previous study has shown that learner engagement is positively associated with prior knowledge (Dong et al., 2020).

The present study provides a potential for the use of mind maps in the classroom. The perceptions of the students in this study suggests that meticulous planning is required to ensure that the maximum benefit is obtained from the use of mind maps in lecture settings. This includes the prior training of students, adequate content related preparation for the class, clear learning objectives, attention to logistic details such as grouping, access to material for map creation and provision of feedback. The time constraints involved in mind mapping may to a large extent be overcome if these measures are taken.

Concept maps have also been successfully used to improve learning in anatomy (Anand and Singel, 2017; Nicoara et al., 2020). A recent study in high-school children suggests that mind maps may be more effective than concept maps in a classroom setting (Samsudin and Irwanto, 2021). Mind maps are more visual, simpler to construct and allow greater room for creativity as compared to concept maps (Davies, 2011; Eppler, 2006). This perhaps makes them more suitable than concept maps for use in contexts like the present study. There may be several reasons why the MMG obtained significantly better test scores for seven out of the eight sessions. Mind maps are thought to assist in the integration of information and thereby promote deep learning (Davies, 2011). Visual representations of information are often easier to comprehend than text or audio (Davies, 2011). This is likely to be even more relevant for a subject like anatomy, which requires learners to visualize structures and morphological changes. The creation of mind maps requires active participation of students, thereby enhancing learning as compared to more passive methods like lectures (Davies, 2011; Pudelko et al., 2012). It has been suggested that the instructional design processes that accompany mapping interventions like working in groups and provision of feedback could be responsible for the positive learning outcomes rather than the mapping process itself (Pudelko et al., 2012). It should be emphasized that teachers who intend to use mind maps need to understand the metacognitive principles that underlie their creation.

This study has some limitations. The quality of the lecturers and facilitators may have influenced the outcome. The study was not teacher-randomized, as there were very few faculty members with sufficient expertise in mind-mapping techniques to conduct sessions for the MMG. In the MMG, students were divided into small groups to create mind maps. This may have had an influence on the test results rather than the creation of mind maps per se. Although the interval between two consecutive sessions was at least two weeks, it is possible that students in the MMG utilized mind maps during subsequent didactic lecture sessions and thereby contributed to a carryover effect. The topics selected for the intervention were based on mutual convenience of the two faculty members who administered the interventions (SM and SD). It was therefore difficult to standardize the difficulty levels of the topics. This may have also influenced the results.

CONCLUSIONS

The results of the present study suggest that the creation of mind maps by students is at least as effective as didactic lectures for achieving learning outcomes in anatomy. There is a need for rigorous clarification studies to understand the extent to which different aspects of mind mapping contribute to learning. More justification studies comparing mind maps and other mapping methods such as concept mapping are also needed. The use of software in the creation of digital mind maps and their role vis-à-vis conventionally drawn mind maps warrants further study as well.

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