Original Article

The Effectiveness of Mind Map as a Teaching Tool for Medical Students

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Abstract

Objective: The mind map has been proven for improving learning effectiveness. We hypothesized that the mind map is helpful to enhance learning outcomes by increasing knowledge retention and student perception for 3rd year medical students at the Faculty of Medicine, Naresuan University.

Methods: A randomized controlled trial study was conducted by comparing the academic performance (MCQs scores for pre-test, immediate post-test, and delayed post-test) and the improvement in academic performance in each group by using the paired *t* test and the students' perception survey (Assessing Student Perspective of Engagement in Class Tool, ASPECT) after attending the class of "osteoporosis" lecture with mind map (intervention group) and lecture with slides (control group).

Results: Thirty-two students were enrolled, but only 28 students completed all the tests (n = 14 in each group). Both groups had no differences in age, gender, academic performance, or pre-test scores (mean of 3.36 in the intervention group vs. 3.34 in the control group). Both groups had similar increases in the immediate post-test score mean of 7.36 (intervention group) and 6.51 (control group) and the delayed post-test score mean of 6.07 (intervention group) and 6.00 (control group). Both groups' post-test and delayed post-test scores increased significantly ($P < .0001$). There was a trend of higher ASPECT scores in the intervention group in the item "The instructor's enthusiasm and class interesting" ($P = .07$).

Conclusions: The lecture with a mind map was effective in improving the academic performance of medical students by increasing students' engagement and attention during the class.

Keywords: Mind map, Active learning, Student engagement, Medical students

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Introduction

Traditional lectures have been the mainstay of undergraduate and postgraduate education for centuries. Although the lecture was a useful teaching tool that was widely used, many lectures today still consist of a unidirectional monologue with little teacher-student interaction. This traditional learning process was usually followed by a knowledge fade, typically a rapid decline.[1-4] Thus, there is an increasing question about the place of this style of teaching in medical education for improving active learning and student engagement.

A mind map was a popular technique for visualizing relationships between information by emphasizing visual representation and the use of color. Buzan[5] created the phrase "mind map" in 1974 for his diagram of key words in a colorful, radiant, tree-like structure. Pictures and graphs were useful for learning new material, along with systematizing and summarizing materials. A mind map provided a deep learning process.[1-5] Educational research has shown that developing mind maps increases thinking, memory, and learning skills.[1-4, 6-7] In addition, students perceived the mind map as fun, interesting, and motivating because of its incorporation of color, symbols, and pictures. Making connections were easier to do because the students had all the information about a specific topic at a single glance. This method was suitable for easy-to-understand hard topics. This technique increased the creative power of a new idea and helped increase the student's motivation to study. The teachers used mind maps to present information to students in lessons. The mind map has been used to encourage critical thinking by inspiring students to assimilate information and understand relations between the clinical and basic sciences.[6-9] The use of colors, images, and keywords in mind maps aids in enhancing memory and retention. Students were able to visualize the relationship between non-linear concepts, which in turn promotes creativity and meaningful learning.[6,7] The mind map also improved long-term memory for better memory formation. Evidence showed that mind maps can facilitate the learning process in interesting and engaging ways, with organization, understanding, and concentration.[6-11]

However, constructing the whole mind map took a lot of time. Thus, the aim of the current study was to prove that a teacher-prepared mind map was an effective tool for teaching in the classroom.[1,2,8,9]

Methods

Study Setting and Study Design

We enrolled the 3rd year medical students during the academic year 2020, Doctor of Medicine (MD) Program, Faculty of Medicine, Naresuan University, Thailand. The MD curriculum is a six-year study. The preclinical rotation (years 1-3) was operated by the faculties of Medicine, Medical Science, and Pharmaceutical Sciences. The clinical rotation (years 4-6) was managed by the Naresuan University Hospital and affiliated hospitals. This study was approved by the Human Research Protection Unit, Faculty of Medicine, Siriraj Hospital, Mahidol University, and the Ethics Committee, Naresuan University Hospital.

This study was a randomized controlled trial (RCT) design. The experiment was designed to confirm the effects of the lecture with a mind map on medical students' learning outcomes. The students were stratified and randomly placed into two groups for the equivalent of their total academic scores: a control group (lecture with slides) and an experimental group (lecture with mind map). The pre-test, immediate post-test, delayed post-test (multiple choice questions, MCQs), and the students' perception survey (The Assessing Student Perspective of Engagement in Class Tool, ASPECT) after attending the lesson on "osteoporosis" were applied to the study. All students had no formal experience on mind map usage. The study was focused on the students' learning outcome by increased knowledge retention (short- and long-term knowledge retention) and student perception of the teaching class.

Instrumentation

Mind Map Presentation and Handout: The mind map presentation was performed by the iMindmapÒ Program version 11. The content of the mind map was the "osteoporosis" topic, which was referenced from Harrison's Principles of Internal Medicine, 20th edition[12] and scheduled for the 4th year medical students. This topic was chosen to minimize the possibility that students had previous knowledge of the teaching material. The core concept of the mind map was "osteoporosis," and the major branches were the major topics. Each major branch included a keyword and an image related to the major topic. The color of each major branch was different (Figure 1). In addition to the presentation, the student could download the mind map file in an electronic PDF file while studying.

The mind map presentation was implemented and received feedback and comments from the volunteer students (4th year medical students) to improve the format prior to the study.

Slides Presentation and Handout: The PowerPoint slides were prepared with the identical content as in the mind map. The PowerPoint file was developed as an electronic PDF file, which the students in the control group could download in the classroom. The slides were already used for teaching the 4th year medical students with positive feedback.

MCQs: The paper-based test (10 MCQs) was developed for the pre-test, immediate post-test, and delayed post-test. The table of specifications and all MCQs items were evaluated by 3 experts using the Item Objective Congruence (IOC) index (an IOC index of 1.00). The internal consistency of MCQs was evaluated by using Cronbach's Alpha Coefficient (*r*). The pre-study coefficient scores (from the 4th year medical students, n = 30) were 0.60.

The ASPECT: Wiggins et al.[13] developed the ASPECT to provide a rapid way to monitor the perception of students' engagement in an introductory biology class with 3 key constructs of cognitive and affective engagement in the active-learning classroom: 1) value of activity, 2) personal effort, and 3) instructor contribution. The 16-item instrument consists of a six-point Likert scale from strongly disagreed to strongly agreed. The previous study reported the coefficient scores (*r*) from 0.78 to 0.91.

Study Procedures and Methods

The RCT process was performed to evaluate the effectiveness of lectures with mind handouts (intervention group) and lectures with traditional slide handouts (control group) (Figure 2). Two versions of the "osteoporosis" topic were delivered: the slide handout and the mind map, both containing identical factual information. Both groups were given by the same teacher to control for lecturer style differences. The lecture was 60 minutes long, and the pre-test, immediate post-test, and delayed post-test lasted 10 minutes each. The pre-test was administered at the start of the lecture, and the immediate post-test was administered after the completion of the lecture. Afterward, the students were asked to complete the questionnaire for the perceptive survey. The delayed post-test was administered one week after the lesson.

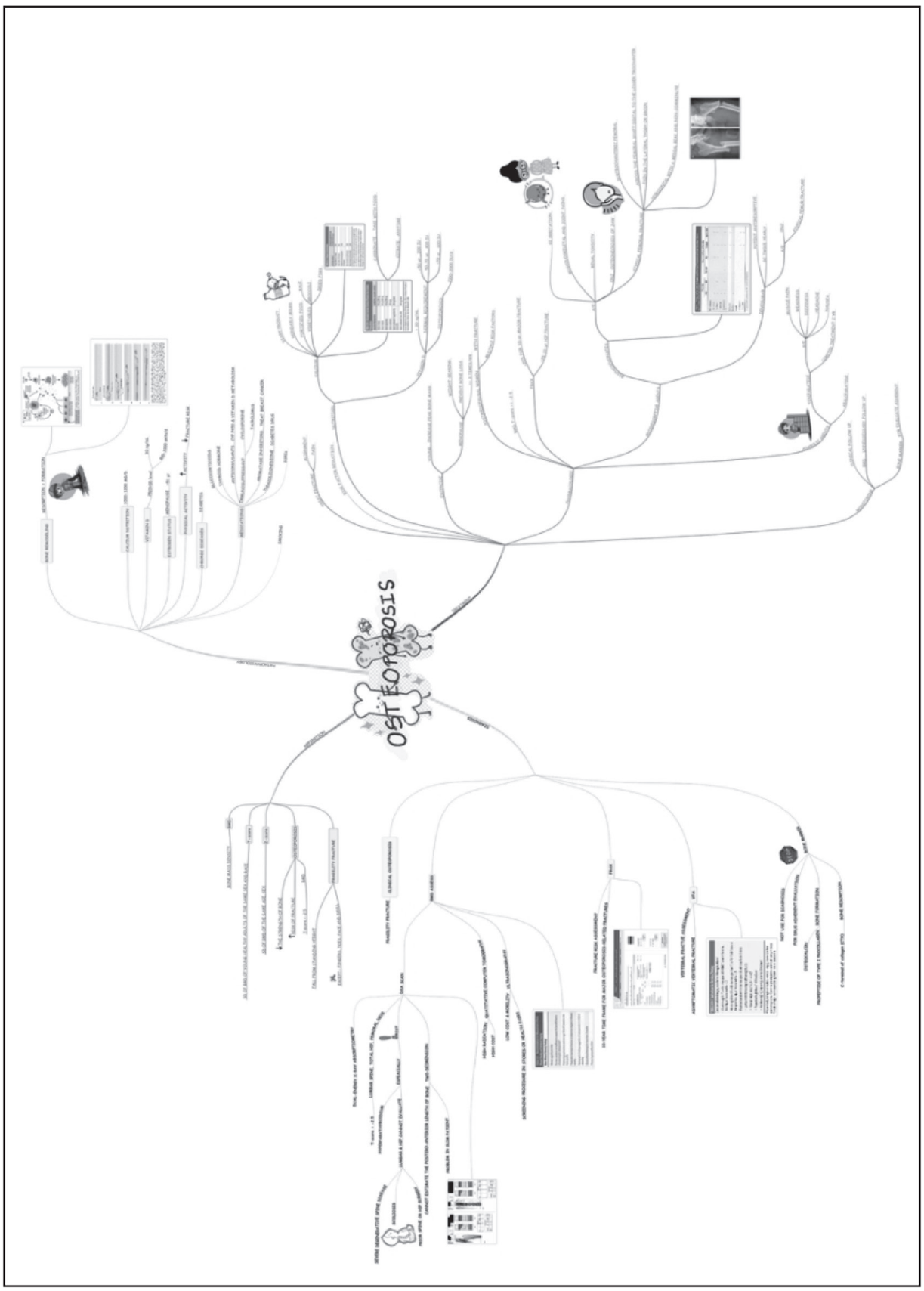

Figure 1 The mind map handout “Osteoporosis”.

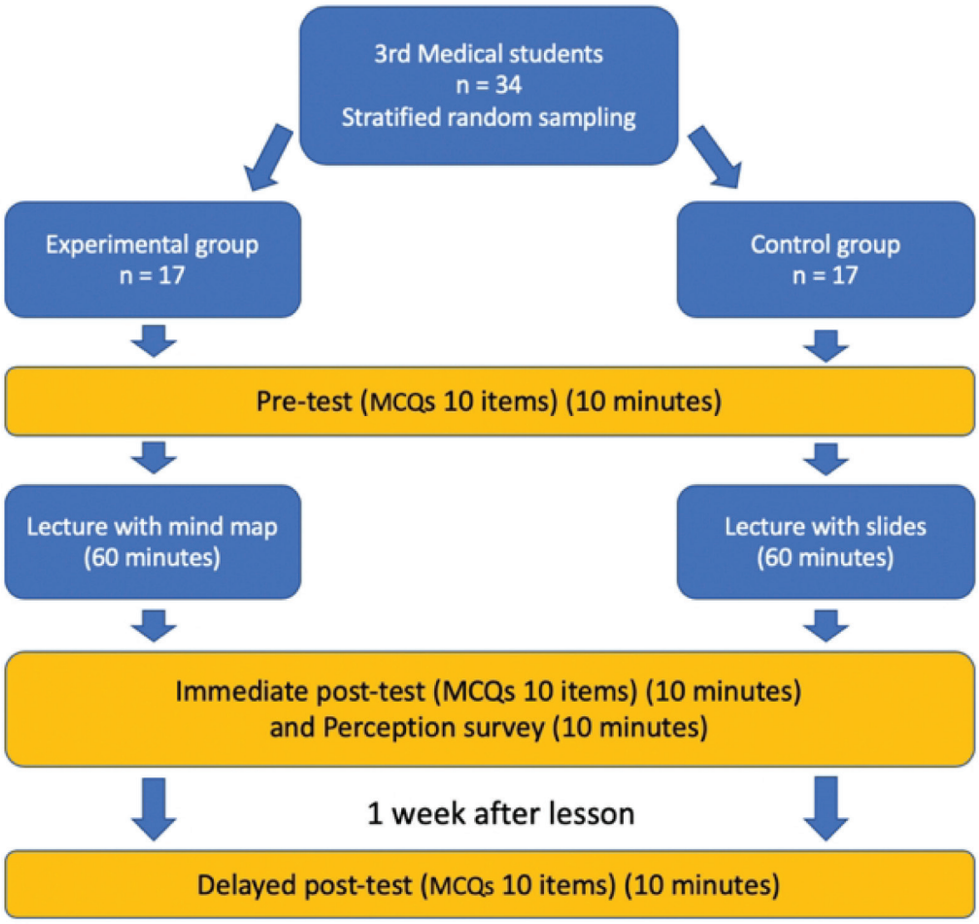

Figure 2 Study Procedures and Methods.

Data Collection and Data Analysis

Participants' age, gender, and performance level (total GPA) were collected as demographic data. The overall scores of all participants (MCQs, ASPECT) were presented in means and standard deviations (SDs). The threshold for statistical significance was set at $P = .05$. Statistical analysis was performed with SPSS Statistics, Version 23.0 (SPSS Inc., Chicago, Illinois, USA). The two independent samples (2-tailed) *t* test and the Pearson Chi-square statistic were used for the comparison between the intervention and the control groups as appropriate. The primary outcome for this study was the difference in total scores in the intervention versus control groups. The sample size calculation was performed and referred to previous study data.[14] A sample size of 13 students per group was needed to answer the research question. In addition, the comparison of the pre-test and the immediate post-test scores (short-term knowledge retention) and the pre-test and the delayed post-test scores (long-term knowledge retention) in each group were accomplished using paired *t* test analysis. The secondary outcome of this study was the differences in the ASPECT scores between the intervention group and the control groups. This data was also analysed by using the independent *t* test (2-tailed).

Results

Demographic Data of the Participants and Comparison of Academic Performance Between the Two Groups

The students voluntarily participated in this study and were randomly enrolled in the control and intervention groups. The students were stratified by total GPA level into 3 groups: high, moderate, and low GPA levels. A random assignment was used to enroll students from each GPA level into both groups.

Initially, a total of 32 students participated in this study. However, four students did not submit to the delayed post-test. Thus, 28 students were finally enrolled in this study (intervention N = 14, control N = 14). There were no statistical differences in age, gender, or academic performance between the two groups (Table 1). Therefore, the demographic data of the participants showed no significant differences between the intervention and control groups. In this study, the mean and SD of the pre-test scores in the intervention and the control group were 3.71 ± 1.38 and 3.64 ± 1.45, respectively. There were no differences in the pre-test scores between the two groups (pre-test scores: t(26) = 0.134, *P* = .895).

To determine the effectiveness of the lecture with mind map compared to the traditional lecture with slide presentation, the academic performance as the immediate post-test scores and the delayed post-test scores were measured and analyzed (Table 1). The mean and SD of the immediate post-test scores and the delayed post-test scores in the intervention group were comparable to those in the control group (post-test scores: t (24.844) = 1.434, *P* = .164 and delayed post-test scores: t (25.102) = .108, *P* = .914). Interestingly, there was a trend toward a higher level of the retention question in post-test scores in the intervention group (mean 4.29 ± 0.73) compared to the control group (mean 3.64 ± 0.93) (*P* = .052).

Table 1 Demographic Data of the Participants and Comparison of Academic Performance Between the Two Groups

	Intervention (N = 14)	**Control (N = 14)**	**Statistic**
Age (years)	21.85 ± 3.11	21.71 ± 3.22	t = 0.119 *P* = .906
Gender			
- Female (N, %)	8 (57.1%)	6 (42.9%)	χ^2 = .0571
- Male (N, %)	6 (42.9%)	8 (57.1%)	*P* = .450
GPA	3.36 ± 0.48	3.34 ± 0.47	t = 0.084 *P* = .934
GPA level			
- High: > 3.50 (N, %)	6 (42.9%)	6 (42.9%)	χ^2= 1.000
- Moderate: 3.01 - 3.50 (N, %)	3 (21.4%)	5 (35.7%)	*P* = .607
- Low: 2.51 - 3.00 (N, %)	5 (35.7%)	3 (21.4%)	
Total pre-test scores	3.71 ± 1.38	3.64 ± 1.45	t = 0.134 *P* = .895
Total immediate post-test scores*	7.36 ± 1.60	6.57 ± 1.28	t = 1.434 *P* = .164
Delayed Post-test scores	6.07 ± 1.90	6.00 ± 1.57	t = 0.108 *P* = .914

Values are presented as N, number of students; and mean ± SD. *Subgroup analysis of retention questions revealed a trend of significant difference (intervention group mean scores of 4.29 ± 0.73, control group mean scores of 3.64 ± 0.93, t = 2.040, *P* = .052).

Comparison of the Academic Improvement in Each Group

Both groups significantly increased their immediate post-test scores and delayed post-test scores (Table 2 and Table 3). In the intervention group, there was a good correlation between the pre-test and the immediate post-test scores (*r* = 0.572, *P* = .033) and the pre-test and delayed post-test scores (*r* = 0.653, *P* = .011).

Reliability of the Instruments

The content validity of the MCQs was based on expert evaluation. The internal consistency reliability (*r*) was used to determine the degree of test score consistency with moderate reliability (*r* = 0.574).

Table 2 Comparison of the Academic Improvement (Pre-test and Immediate Post-test Scores) in Each Group

	Pre-test scores	**Immediate Post-test scores**	**t**	***P*-value**
Intervention group (lecture with mind map) (N = 14)	3.71 ± 1.38	7.36 ± 1.60	9.787	< .001*
Control group (lecture with slides) (N = 14)	3.64 ± 1.45	6.57 ± 1.28	6.176	< .001*

Values are presented as N, number of students; and mean ± SD.

*Statistical significance at *P*-value < .05

a Correlation between the pre-test scores and the immediate post-test scores of the intervention group was 0.572 (*P* = 0.033).

b Correlation between the pre-test scores and the immediate post-test scores of the control group was 0.160 (*P* = .585).

Table 3 Comparison of the Academic Improvement (Pre-test and Delayed Post-test Scores) in Each Group

	Pre-test scores	**Delayed Post-test scores**	**t**	***P*-value**
Intervention group (lecture with mind map) (N = 14)	3.71 ± 1.38	6.07 ± 1.90	6.096	< .001*
Control group (lecture with slides) (N = 14)	3.64 ± 1.45	6.00 ± 1.57	4.359	.001*

Values are presented as N, number of students; and mean ± SD.

*Statistical significance at *P*-value < .05

a Correlation between the pre-test scores and the delayed post-test scores of the intervention group was 0.653 (*P* = .011).

b Correlation between the pre-test scores and the delayed post-test scores of the control group was 0.102 (*P* = .729).

Comparison of the ASPECT Scores Between the Two Groups

The 16 items were grouped into 3 categories: value of group activity, personal effort, and instructor contribution. There were no differences in the mean of summary scores among all items and each subgroup between the intervention group and the control group. However, there was a trend of higher scores in the intervention group (5.50 ± 0.65) compared to the control group (5.00 ± 0.78) in the item "The instructor's enthusiasm made me more interested in the *"Osteoporosis"* activity" (*P* = .07) (Table 4).

Table 4 Comparison of the Satisfaction Scores Between the Two Groups

	Intervention (N = 14)	Control (N = 14)	t	*P*-value
1. Explaining the material to my group improved my understanding of it.	5.57 ± 0.65	5.36 ± 0.50	0.983	.335
2. The instructor's enthusiasm made me more interested in the *"Osteoporosis"* activity.	5.50 ± 0.65	5.00 ± 0.78	1.836	.070
3. Having the material explained to me by my group members improved my understanding of the material.	5.36 ± 0.63	5.14 ± 0.95	0.703	.489
4. Group discussion during the *"Osteoporosis"* activity contributed to my understanding of the course material.	4.86 ± 0.53	4.64 ± 0.93	0.748	.461
5. The instructor put a good deal of effort into my learning for today's class.	5.36 ± 0.74	5.07 ± 0.92	0.905	.374
6. I had fun during today's *"Osteoporosis"* activity.	5.14 ± 0.77	4.64 ± 0.84	1.639	.113
7. Overall, the other members of my group made valuable contributions during the *"Osteoporosis"* activity.	4.86 ± 0.77	4.36 ± 1.15	1.351	.190
8. The instructor seemed prepared for the *"Osteoporosis"* activity.	5.57 ± 0.51	5.50 ± 0.65	0.322	.750
9. I would prefer to take a class that includes this *"Osteoporosis"* activity over one that does not include this activity.	4.57 ± 0.94	4.57 ± 0.85	0.000	1.000
10. I am confident in my understanding of the material presented during today's *"Osteoporosis"* activity.	5.21 ± 0.70	4.93 ± 0.62	1.147	.262
11. I made a valuable contribution to my group today.	4.93 ± 0.73	4.57 ± 1.02	1.068	.296
12. The instructor and TAs were available to answer questions during the *"Osteoporosis"* activity.	5.36 ± 0.74	5.00 ± 0.55	1.439	.162
13. The *"Osteoporosis"* activity increased my understanding of the course material.	5.43 ± 0.51	5.36 ± 0.63	0.328	.746
14. I was focused during today's *"Osteoporosis"* activity.	5.36 ± 0.74	5.21 ± 0.70	0.523	.605
15. The *"Osteoporosis"* activity stimulated my interest in the course material.	5.43 ± 0.65	5.29 ± 0.73	0.550	.587
16. I worked hard during today's *"Osteoporosis"* activity.	4.86 ± 1.03	4.86 ± 0.95	0.000	1.000
Summary scores of all topics	83.36 ± 7.15	79.50 ± 6.49	1.494	.147
Summary scores of values of activity factor	46.79 ± 3.83	44.29 ± 4.07	1.675	.106
Summary scores of personal effort factor	15.50 ± 1.70	14.50 ± 1.40	1.700	.102
Summary scores of instructor contribution factor	21.07 ± 2.46	20.71 ± 2.27	0.399	.693

Values are presented as N, number of students; and mean ± SD.

Discussion

In this study, we focused on the effectiveness of the mind map as a teaching tool for medical students by assessing academic performance improvement and knowledge retention in each group. We measured not only the differences between pre-test and immediate post-test scores (short-term knowledge retention), but also the differences between pre-test and delayed post-test scores (long-term knowledge retention) between both groups. The results showed no differences in basic characteristics or based-line academic scores in either group. In comparison to the students in the lecture with slides group, the students in the lecture with mind map group had significantly improved in their academic performance levels and knowledge retention. The mean of the immediate post-test scores and the delayed post-test scores of the lecture with mind map group was higher than the lecture with slides group. However, it did not reach the statistically significant threshold. Thus, the effectiveness of the lecture with a mind map was equivalent to that of the lecture with traditional slides for teaching medical students. Nevertheless, the effectiveness of the lecture with a mind map was not superior to that of the lecture with traditional slides.

Our study findings were consistent with previous studies that have been reported about the use of mind maps as teaching tools in the teaching classroom for medical students on various topics such as cell biology, growth and development, self-reflection technique, diagnostic and critical thinking process, and PBL class.[1,8,11,14-20] Our results were comparable to several studies regarding the effectiveness of mind maps and traditional lectures, with similar knowledge acquisition levels. Interestingly, there was a trend toward a higher level of the recall part of the post-test scores in the intervention group ($P = .052$) in our study.

In contrast to our study, previous studies reported significantly increased knowledge by using mind maps as teaching tools.[14,21] However, there were only a few experimental randomized control trial studies.[11,14,16] In addition, the topics that showed the superiority of mind maps as teaching tools included recall memory related to vocabulary. Haji[22] also conducted a study to investigate the effects of teaching with a mind map compared with traditional teaching methods of vocabulary used in the writing of Iranian EFL learners. At the end of instructions to both groups, the post-test showed that the experimental group outperformed the control group. The delayed post-test performed after a month, revealed that the long-term effect of the mind map strategy was significantly effective against the improvement in vocabulary used in writing tasks. However, Dhindsa, et al.[22] reported that use of a mind map technique improved students' achievement in science. The students who were taught science using a mind map technique had significantly higher achievement scores than students who were taught using traditional teaching methods.

In this study, the students' perception levels in lectures with the mind map group were comparable to those in lectures with slides. Although the summary of overall topics of the ASPECT scores was higher in the lectures with the mind map group. There were no statistically significant differences. However, the results showed the trend of higher students' perception level in the topic "the instructor's enthusiasm made me more interested in the "osteoporosis" activity" in the lectures with the mind map group (5.50 ± 0.65) compared to the lectures with the slides group (5.00 ± 0.78, $P = .07$). The students in lectures with mind maps tend to be more enthusiastic and engaged in the class in all three aspects: the value of group activity, personal effort, and instructor contribution. It was consistent with previous studies that reported on the students' motivation, especially on intrinsic motivation as the main initial key step of the learning process based on the information processing theory.[23,24] Previous studies have also reported a correlation between intrinsic goal orientation and the task value component. However, the mean ASPECTS scores in the lectures with mind maps were not higher than in the lectures in our study. It was possible for several reasons, such as the time limit on the lecture class duration, the difference in the study population, and the limited number of participants. Given the time limit on the lecture class duration, the students had no time to review the contents. The mind map may help students by increasing attention and motivation, along with helping for scheme making by summarizing main concepts with figures and lines. However, the students had no time

to review the content and use the rehearsal process in the information processing theory for gaining long-term memory.

Our study had a significant strength with the study design as an RCT study. There were no differences in participants' demographic characteristics or baseline academic performance levels in either group. There were separate lecture classes for the intervention and control groups, which limited the subject contamination between both groups. Moreover, our study instruments were developed and considered for validity and reliability.

However, there were limitations to our study. Firstly, given the process of measuring delayed post-test as reflected on long-term knowledge retention, there were 4 students (12.5%) who did not complete the delayed post-test evaluation. We have awarded this mortality threat. However, the number of participants in this study was still an adequate sample based on the sample size analysis (n = 13 in each group). Secondly, the lectures in both groups were conducted in 60-minute classroom settings. In some students, this process might disturb the learning process by limiting the process of reviewing the lecture content. Thus, we stratified the students in both groups by GPA levels. Thirdly, we did not have information on the learning preferences, such as students' VARK learning styles, prior to the study. In previous studies, the mind map was associated with visual learners. Thus, there might be an impact on the effectiveness of the lecture with the mind map in the classroom. Fourthly, the students might have some differences in baseline attitude, motivation, and familiarity with the mind map used prior to the study. Some students might have used mind maps as a self-learning method for summarizing their learning topics prior to the study. The more students understand and become familiar with the process of mind map presentation, the more their learning process might be impacted. Finally, the differences in population and institutional structures may limit the generalizability of the results.

In conclusion, the lecture with mind map was an effective teaching tool for medical students comparable with the traditional lecture. The mind map helped medical students in learning new subjects by improving academic performance and knowledge retention. In addition, the students' engagement perceptions scores in the lecture with the mind map group trend to be higher compared to the traditional lecture with slides, especially in the topic of the interesting of the instructor and class. Based on information processing theory, the mind map was found to increase students' attention and motivation to learn new topics and gain medical knowledge.

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Conflict of interest. All authors report no conflicts of interest relevant to this article.

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