ORIGINAL ARTICLE

EXPLORING THE USE OF MIND MAPPING FOR LEARNING ANATOMY IN UNDERGRADUATE MEDICAL STUDENTS: A MIXED METHODS STUDY

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Background: Anatomy is an important preclinical subject often taught through didactic lectures to undergraduate medical students. To improve learning outcomes, mind mapping presents a promising alternative by visually organizing information and promoting active learning. The objectives of the study were to compare the effectiveness of mind mapping versus didactic lectures in improving anatomy learning and explore the experiences of undergraduate medical students with using mind mapping. **Methods:** This study used a partially mixed sequential design with a randomized controlled crossover in Phase 1 to compare mind mapping and didactic lectures for anatomy learning. A total of 150 first-year medical students participated, with sessions conducted on shoulder and elbow joint topics. Post-session test scores were analyzed using SPSS, ensuring assumptions for parametric testing were met. In Phase 2, 26 students from different performance levels took part in focus group discussions to explore their experiences. Data was thematically analyzed using Braun and Clarke's method, ensuring rigour through member checking, triangulation, and reflexivity. **Results:** The students who learned anatomy through mind mapping scored higher than those who were taught through didactic lectures. For topic 1 and 2, the *p*-values were 0.02 and 0.01 respectively, indicating a statistically significant difference in scores between the mind mapping and didactic lecture groups. The qualitative phase revealed five themes: Initial perceptions and expectations, Advantages of mind mapping, Limitations and improvement areas, Mind mapping versus traditional learning methods, and Recommendations. **Conclusion:** This study highlights mind mapping as an effective tool for improving academic performance, engagement, and collaboration in anatomy education. It demonstrates that mind mapping offers advantages over traditional teaching methods. Incorporating mind mapping into teaching practices can improve understanding of anatomical concepts and learning outcomes in medical students.

Keywords: Mind mapping; Anatomy; Didactic lectures; Undergraduate medical students

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INTRODUCTION

Anatomy is one of the major subjects taught during the preclinical years in medical colleges across Pakistan. It constitutes 41% of the teaching hours allocated to basic sciences subjects in first two years of MBBS.[1] Although anatomy has a fundamental role in clinical practice, it is perceived as a memory-based discipline.[2] Research indicates that students face difficulties in learning, retaining, and applying anatomical knowledge due to various reasons such as content overload, difficulty in visualizing complex anatomical structures, and passive teaching and learning methods.[3,4] To address these issues, it is important to assess and revise the existing teaching methods for anatomy. Teachers mostly opt for didactic lectures to teach anatomical concepts.[5] Didactic lectures, while efficient in disseminating extensive information to a large audience, often lack the element of meaningful exchange of information, leading to passive learning.[6] Moreover, when students are not actively engaged in the learning process, they start perceiving anatomy as a subject that could only be learned through rote memorization.[4] Hence, students resort towards exam-cantered approaches such as cramming, note taking, and highlighting, leading to superficial learning instead of developing deep understanding of the subject. This approach hampers their ability to apply anatomical knowledge in clinical settings.[7] Clinicians have observed similar issues, raising questions about the effectiveness of current teaching methods.[8]

Recognizing the limitations of didactic lectures, literature advocates for using alternative teaching methods that promote active learning and critical thinking.[9] One such innovative learning method is mind mapping, which has emerged as a

promising tool to enhance learning.[10] Introduced by Tony Buzan, mind mapping is a creative way to manage information using text, images and colors, giving meaning to the information as a whole.[11] The mind mapping begins with main topic in center, with subtopics radiating out from it.[12] Combining mind mapping with other techniques like using illustrations, color coding, and line play enables the sequencing of thought process, enhancing cognitive memory by 32%.[11]

Despite the existing evidence supporting the use of mind mapping,[13–17] its implementation in teaching anatomy in Pakistan remains an underexplored territory. The current study aims to address this gap by investigating the impact of incorporating mind mapping in teaching anatomy. By comparing knowledge scores and exploring perspectives of medical students about mind mapping, this study seeks to evaluate the effectiveness of mind mapping as a pedagogical tool in anatomy education. Through this research, we aim to contribute valuable insights into the ongoing efforts to revolutionize anatomy education in Pakistan, making it more clinically relevant, engaging, and effective in preparing medical students for independent clinical practice.

To address current gap in our understanding, the following research questions were designed:

1. What is the comparative effectiveness of mind mapping versus didactic lecture in improving understanding of anatomy among undergraduate medical students?
2. What are the perceptions of undergraduate medical students regarding the effectiveness of mind mapping for learning anatomy?

MATERIAL AND METHODS

We used partially mixed sequential equal status design as it aligned with our study objectives.[18] The quantitative phase compared students' test scores from mind mapping and didactic lectures, followed by a qualitative phase exploring students' experiences with mind mapping to learn anatomy.

The study spanned over six months following ethics approval. We engaged two teachers who taught anatomy to first-year medical students at the study site. After obtaining written informed consent, the teachers participated in a training session on mind mapping conducted by the principal investigator, who maintained reflexivity to minimize bias due to their dual role as trainer and researcher. After training, two topics from the anatomy of upper limb were selected. The shoulder and elbow joints, along with their associated muscles, were selected as the focus because they were part of the scheduled teaching calendar at the time of the study. The teachers collaboratively created lesson plans for these topics: one plan utilized mind mapping and the other used didactic lecture. This collaboration ensured standardization of learning objectives, minimizing potential teacher bias. The teaching sessions were scheduled so that while one teacher delivered a didactic lecture to one group of students, the other teacher taught the same topic to the other group using mind mapping. To evaluate the effectiveness of each method, for each specific topic covered, a separate test consisting of ten pre-validated multiple-choice questions was prepared, reviewed by experts for content and clarity before use. The multiple-choice questions (MCQs) used for assessment were selected from the institution's existing item bank. These questions had previously undergone item analysis and were pre-validated for content accuracy, difficulty level, and discrimination index. Only those items with acceptable psychometric properties and alignment with the topic-specific learning objectives were included in the study.

Phase 1 (Quantitative): Comparing the effectiveness of mind mapping and didactic lecture for learning anatomy in first year medical students

Participants

Phase 1 of the study followed a randomized controlled crossover design. A total population approach was used, including all 150 first-year medical students enrolled at a private medical college, to ensure complete representation and eliminate selection bias. Since the intent was to compare learning strategies across the entire cohort, no exclusion criteria were applied at this stage. To allocate participants into two equal groups (Group 1 and Group 2), systematic randomization was employed. Students were listed by roll number, and a random starting point was selected. From that point, every second student was assigned to Group 1, while the remaining students were placed in Group 2. This approach ensured a balanced and unbiased distribution across groups while maintaining the benefits of a randomized allocation strategy.

An introductory class was conducted on 'mind mapping' for participants before the sessions. During mind mapping session, G1 was further subdivided into eight small groups. The teacher shared learning objectives of the topic, and students created mind maps using chart papers and colored markers, consulting various available resources. The session concluded with presenting and discussing mind maps followed by MCQs test. Simultaneously, G2 learned the same topic through one-hour didactic lecture followed by MCQs test. After two weeks, for the second topic, G1 experienced the didactic lecture, while G2 engaged in mind mapping session. This approach ensured that all participants experienced both teaching methods. The process is illustrated in figure-1.

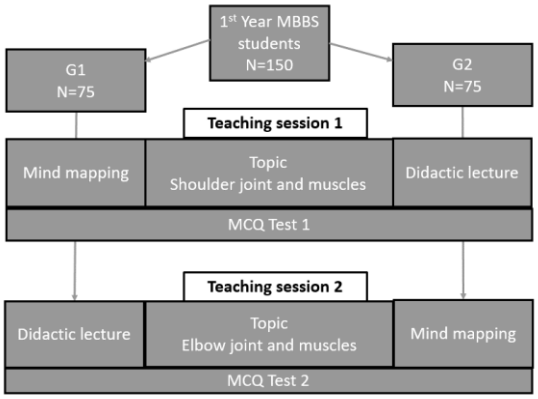

Figure-1: A schematic process of Phase 1 study design

Using IBM SPSS version 21, the mean and standard deviation (SD) of test scores for both teaching methods were calculated. Before applying the independent sample t-test to compare group differences, the assumptions of normality and homogeneity of variances were assessed and found to be satisfied. This justified the use of the t-test as an appropriate parametric method. A *p*-value of less than 0.05 was considered statistically significant.

Phase 2 (Qualitative): Exploring the experiences of undergraduate medical students regarding the effectiveness of mind mapping for learning anatomy

The phase 2 was qualitative exploratory involving three focus group discussions (FGDs) with first-year medical students. The aim was to explore their experiences using mind mapping to learn anatomy.

Students were categorized into high, average, and low performance groups based on their Phase 1 test scores. The average score across both topics was approximately 8.0 (SD ≈ 1.0). Using this distribution, students were stratified as high performers: Score ≥ 9.0, average performers: Score between 7.5 and 8.9, and low performers: Score <7.5. This criterion allowed for consistent and transparent classification based on academic performance. All 150 first-year medical students were invited to participate in Phase 2 via email. A total of 26 students volunteered and were assigned to three focus groups using purposive sampling, ensuring a balanced mix of performance categories. Table 1 presents the distribution.

Table-1: Distribution of participants by performance category and gender across focus groups

Focus group	Performance categories			Total number of students in group N=26
	High scorers N=11	Average scorers N=7	Low scorers N=8	
1	4	2	3	9
2	4	2	2	8
3	3	3	3	8

An interview guide was developed after an extensive literature review and reviewed by two medical educationists. They confirmed the relevance and adequacy of the questions for addressing the research questions. The guide consisted of main questions related to advantages, disadvantages, and comparison of mind mapping with other methods along with the probes. The guide was pilot-tested with two first year students for clarity and comprehensibility and feedback was used to refine it. Pilot test results were excluded from final analysis.

The logistics were finalized according to the feasibility of the participants and written informed consents were obtained. Three FGDs were conducted to gather in-depth information from the participants. Each session was audio-recorded with permission of the participants and lasted for 45 to 60 minutes. The moderator ensured all topics were covered while allowing participants to share their thoughts freely. Field notes were also taken to supplement the data.

Audio recordings were transcribed verbatim and shared with participants for member checking to ensure transparency of data.[19] Data was analyzed using Braun and Clarke's thematic analysis method, with Atlas.ti software, version 9.1.3.0 (Scientific software development, Berlin, Germany).[20] The analysis followed an iterative process. Initially, the transcripts were read thoroughly to familiarize with the data. Over fifty initial codes were generated inductively, focusing on key features of the data related to the research questions. These codes were then organized into broader categories, which ultimately led to the identification of themes that represented the core aspects of participants' experiences. The coding framework was refined iteratively. During subsequent rounds of review, the research team revisited, revised, and redefined codes as new insights emerged. By the final stage, the coding framework included 30 refined codes, which were grouped into five main themes and their corresponding subthemes. To ensure rigour, strategies such as member checking and peer debriefing were employed. Triangulation was achieved through involvement of multiple researchers in analysis. Reflexivity was maintained through ongoing reflection on researchers' positionality and potential influence on interpretation.

RESULTS

Phase 1 (Quantitative):

For Topic 1 and Topic 2, students taught with mind mapping scored higher than those taught with didactic lectures, with *p*-values of 0.02 and 0.01 respectively, indicating statistical significance. Detailed mean scores and standard deviations for each group are presented in Table-2.

Phase 2 (Qualitative):

The qualitative data analysis revealed five overarching themes as summarized in Table 3.

Table-2: Comparison of mean test scores between the two groups

Topic	Teaching Method	Group name- n= number of students present in each class	Mean Score	(SD)	*p*-value
Topic 1 (Shoulder joint and muscles)	Mind mapping	G1 (n = 72)	8.24	1.00	0.02
	Didactic lecture	G2 (n = 72)	7.84	0.86	
Topic 2 (Elbow joint and muscles)	Mind mapping	G2 (n = 71)	8.23	1.24	0.01
	Didactic lecture	G1 (n = 73)	7.75	1.05	

Table-3: Summary of themes and subthemes

Themes	Subthemes
Initial perceptions and expectations	Anticipated usefulness for organizing information Concerns about time management Expectations based on visual learning preferences
Advantages of mind mapping	Enhanced understanding and retention Increased interest and motivation Improved peer collaboration
Limitations and improvement areas	Challenges in managing time Difficulty deciding what to include Maps becoming too detailed or cluttered Need for training and clear guidelines
Mind mapping vs. traditional learning	Preference for interactive, visual methods Better conceptual understanding Risk of over-detailing leading to confusion
Recommendations	Strong endorsement by students Suitability for visual learners Need for structured training and practice

Initial perceptions and expectations

The majority participants expected mind mapping to be an interesting way to organize information. A few participants had concerns about time management with mind mapping. Some visual learners hoped mind mapping would help them visualize complex anatomical structures and their connections. As one participant said:

> *'To be honest, I was excited as I am a visual learner. I learn better when I see things…so I expected it to be more interactive enabling me to see connections between things.' (P6)*

Advantages of mind mapping

According to participants, the mind mapping offered several advantages.

Enhanced understanding and retention:

Majority participants reported that mind mapping significantly improved their understanding and retention of anatomical concepts. The participants shared various examples where their learning improved with this technique. For instance, one student said:

> *'I think mind mapping helped me to grasp and retain difficult topics. For example, I found brachial plexus a bit difficult to retain, but with mind map, it became simpler for me.' (P4)*

Increased interest and motivation:

Many participants noted that mind mapping positively impacted their interest towards anatomy. It fostered sense of ownership and boosted motivation as students felt responsible for their own learning.

Improved peer collaboration:

Participants reported creating mind maps through peer collaboration, significantly improved their overall learning experience, offering a detailed overview and better time management. For instance, a participant said:

> *'I think, making mind maps is easier when we work in groups. We can divide the topics and then combine our work. This takes lesser time… and also we learn better when we explain our parts in group discussion.' (P9)*

Limitations and improvement areas

Participants highlighted a few limitations, such as difficulty in preventing their maps from becoming too detailed and cluttered. Additionally, some students struggled with deciding what information to include in their maps. Time management was most commonly reported challenge. For example, one participant said:

'Studying anatomy with mind map was quite helpful, but I faced difficulty in managing time. You know, anatomy is extensive that it took longer than I expected.' (P13)

The participants pointed out several areas where improvements could enhance the usability of mind maps. They suggested that creating mind maps with collaborative efforts could optimize time. Others emphasized the need for training sessions focused on using mind mapping software. Majority students believed that providing them with structured criteria would help them focus on the most important information to include in mind maps. For instance, a participant shared:

'Initially, it was difficult for me to decide what information to include. It would help if there were clearer guidelines on creating mind maps.' (P6)

Mind mapping versus traditional learning methods

Most participants preferred mind mapping over other methods to learn anatomy because of its interactive approach. They noted that unlike lectures, visual layout of mind maps enabled them to understand relationships between different anatomical structures. However, for some participants, overly detailed mind maps compromised the efficient learning. As one participant said:

'One benefit [of using mind maps] is organizing information aesthetically. A disadvantage is adding too much details makes it congested and hard to read.' (P10)

Recommendations

All participants reported positive experiences with using mind maps for learning anatomy. They consistently highlighted its advantages in improving their learning experience. According to some students, mind mapping is particularly useful for visual learners. The majority indicated that they would recommend mind mapping to other students, especially for learning anatomy. Despite the overall positive feedback, the participants suggested that the efficacy of mind mapping depends on its correct use. They recommended that formal training and practice could enhance their learning experience. For example, a student said:

'I enjoyed using mind maps and I will definitely recommend it… because it can help many students if used properly. It requires training and practice to master.' (P5)

DISCUSSION

In our study, the students who used mind maps scored higher than those who studied anatomy through didactic lecture, indicating effectiveness of mind mapping for understanding anatomical concepts.[5,21] Some factors that were not controlled in the study might have affected the results. For example, students may have had different levels of previous knowledge, interest, or ways they prefer to learn. Even though we tried to keep the teaching content and delivery the same, these differences could have influenced how well students performed and how they felt about each teaching method. However, mind mapping is widely acknowledged for its role in boosting academic performance by structuring complex information, clarifying concepts, and enhancing memory retention.[22] Mind mapping works on radiant thinking pattern, which stimulates all parts of brain, promoting creative and analytical thinking, improving learning outcomes.[23] A meta-analysis on mind mapping indicated that it significantly enhances learning outcomes across various educational settings.[24]

The qualitative phase provided deeper insights into the students' experiences with mind mapping. Initial perceptions of students were positive, as they expected mind mapping to be an innovative method to learn anatomy. Visual learners, in particular, expressed enthusiasm for mind mapping because of its appealing visual format.[25] Mind mapping involves both cerebral hemispheres. The right hemisphere is associated with creativity and visualization, while the left hemisphere is linked to logical thinking and organization.[26] By activating both sides, mind maps create a holistic learning experience, a trend reported in our study.[23] The visual layout of mind maps helps in chunking of complex information, making it easier to recall. Mind mapping allows students to take responsibility of their learning process, boosting intrinsic motivation, contributing to life-long learning.[27]

Mind maps, by nature, are designed to organize information visually and hierarchically.[23] However, some participants observed that their maps became cluttered due to information overload in anatomy. When students attempted to include every detail, their mind maps became chaotic and lost clarity, making them less effective.[28] Providing a standardized approach to creating mind maps could assist students in distinguishing essential and supplementary information. Creating a comprehensive mind map requires a substantial time investment, another challenge reported in our study.[5] Creating mind maps collaboratively could address the issue of time management. Collaboration would also allow inclusion of diverse perspectives, enriching the final mind map. Additionally, participants emphasized the need for training sessions focused in using mind mapping software. There are many mind mapping software options, like FreeMind, Xmind, and IMindMap, which offer simple design, better readability, unlimited space, easy use of images, and different sharing options.[16] Such training could enable

students to organize the key information, and manage the time required in creating mind maps. Overall, participants reported positive experiences with mind mapping and recommended it as a valuable technique for learning anatomy.

There are certain limitations of this study. The MCQs may not fully capture the depth of understanding gained through different teaching methods. In the qualitative phase, purposive sampling may lead to selection bias. Differences in teaching effectiveness between the two methods might be influenced by teacher expertise. While efforts were made to ensure comparable groups, variations in students' baseline understanding may have influenced the outcomes. Since the study was conducted at a single medical college, the findings may have limited generalizability to other institutions with different curricula, student populations, or teaching environments. While the results provide valuable insights into the use of mind mapping in anatomy teaching, further studies across diverse educational settings are needed to strengthen the external validity and broader applicability of these findings. Another limitation is the short duration of the study, which does not allow for assessment of long-term retention of anatomical knowledge. Future research could include longitudinal studies to explore whether mind mapping has a sustained impact on learning and memory over time.

CONCLUSION

The findings of this study underscore the potential of mind mapping as an effective learning tool. Mind mapping not only improves students' academic performance but also enhances their engagement, motivation, and collaborative learning experiences. The positive outcomes observed in this study suggest that mind mapping should be considered a valuable complement to traditional teaching methods in anatomy education. However, to fully utilize its benefits, proper training and guidance are essential.

Statements and Declaration

Conflict of interest

The authors have no conflicts of interest to disclose related to the submitted work.

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The authors did not receive funds from any organization for submitted work

Ethical Approval

The ethical approval for this study was granted by ethics review committee under the reference # WM&DCR/R&D (ERB)/2024/132.

Consent to participate

All participants in this study were provided with detailed information about the research and written informed consent was obtained from each participant.

AUTHORS' CONTRIBUTION

AZ: literature search, conceptualization of study design, data collection, data analysis, write-up, proofreading. ZG: literature search, obtaining ethics approval, data collection, proofreading. HS: literature search, data collection, data analysis. NF: data analysis, write-up, proof reading. MG: literature search, conceptualization of study design, proof reading.

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