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CONCEPT MAPPING AND MIND MAPPING IN PROBLEM-BASED LEARNING FOR MEDICAL EDUCATION

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ABSTRACT

Background: Medical education's heavy learning load requires learning technologies that can integrate varied instructional information. **Objective:** This study aims to synthesize evidence on the use of concept maps and mind maps in Problem-Based Learning (PBL) within medical education through a systematic review process. **Methods:** The research involved identifying, screening, assessing eligibility, and thematically synthesizing relevant literature. Out of 128 publications identified, 11 studies met the inclusion criteria and were analyzed in depth. **Results:** The results indicate that concept maps support hierarchical integration of basic and clinical concepts, enhance meaningful learning, and strengthen critical thinking, clinical reasoning, and problem-solving skills. In contrast, mind maps were found to be effective for simplifying complex information, improving initial comprehension, enhancing memory retention, and organizing ideas in small-group discussions. Several assessment approaches were identified, including structural rubrics, argument-based evaluation, clinical problem-solving performance measures, and the MMAR rubric. **Conclusion:** In conclusion, both visual mapping tools offer significant pedagogical value in PBL but require structured training and guidance to achieve optimal effectiveness. A sequential integration of mind maps followed by concept maps has the potential to further enhance learning outcomes for medical students.

INTRODUCTION

The challenges inherent in medical education, marked by a substantial learning burden, necessitate the development of learning tools capable of effectively integrating diverse forms of educational information. Prior research Apperson and Ausubel[1,2] has demonstrated that Problem-Based Learning (PBL) and the autonomous application of mind mapping effectively support constructivist learning theory, which is foundational to contemporary medical education. This provides an opportunity to conduct an in-depth review of the relationship between mind mapping and the PBL method within an integrated study.

Medical students encounter considerable difficulties in assimilating and analyzing extensive information from various viewpoints concerning specific diseases within constrained timeframes. Effective learning and the cultivation of engaged learners are crucial for tackling these challenges. The organization of information is a fundamental process in efficient learning. An active learner does not develop spontaneously; instead, three critical conditions must be met in the learning process: 1) relevant prior knowledge, 2) meaningful material, and 3) the selection of effective learning strategies. The quality of an active learner is determined by an appropriate combination of these three conditions[1].

Meaningful learning is central to constructivist theory, encompassing the development of cognitive frameworks that enhance analysis, memorization, and comprehension of interconnected concepts[2]. The PBL approach clearly embodies these principles and has been extensively adopted in medical schools globally.

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Project-Based Learning (PBL) not only embodies constructivist learning principles but also improves memory retention by engaging students in clinical reasoning, critical thinking, and self-directed learning[3,4].

Apperson[2] indicated that visual patterning techniques for information organization are more effective for many students than table-based methods. The use of flowcharts, diagrammatic schemes, labeled graphs, and visual representations to connect multiple topics facilitates the memorization and application of new information by students. The characteristics correspond with the main role of mind maps as visual learning instruments[5]. Therefore, this study aims to systematically review the evidence on the use of concept mapping and mind mapping within Problem-Based Learning in medical education, with a focus on their definitions, applications, effectiveness, assessment methods, and associated challenges.

METHODS

This research utilized a systematic review methodology as outlined by Cook and West[6]. The process involved formulating research questions concerning the population and outcomes, assessing the suitability of a systematic review design, assembling a review team, and creating a review protocol. Eligible articles were identified through searches in multiple databases utilizing the terms concept map, mind map, problem-based learning, effectiveness, medical education, and factor. Inclusion and exclusion criteria were implemented for all identified studies, screening titles, abstracts, and full texts to eliminate articles that did not provide detailed information on student respondents, including year of study, gender, or nationality. Duplicate records were eliminated, and essential information from each article, including study design, participants, interventions, comparisons, and outcomes, was extracted independently by two reviewers whenever feasible.

A total of 128 articles were initially retrieved; after multiple screening stages, 11 articles met the eligibility criteria for detailed review. The data obtained from the selected studies encompassed publication characteristics, respondent demographics, methodological features, primary findings, and reported implications. The analysis employed qualitative thematic analysis as outlined by Bearman et al.[7], initiating with the coding of key concepts, summarization of meanings, and interpretation of emerging themes. For thoroughness and consistency, the study team repeatedly evaluated and cross-checked all categories and trends..

RESULTS

A cross-study matrix was developed to visualize the synthesized thematic findings (Table 1).

Table 1. Summary of Findings on the Use of Concept Maps and Mind Maps in Medical PBL

Focus Area	Concept Maps	Mind Maps
Learning Theory Basis	Constructivism; Assimilation theory [8,9]	Constructivism; Radiant thinking [10]
Primary Function	Hierarchical integration of basic–clinical concepts; clinical reasoning	Creative visualization and summarization; memory enhancement
Effectiveness	Improves critical thinking, diagnostic reasoning, and meaningful learning [11,12]	Enhances comprehension, recall, and organization of ideas [9,13]
Assessment Methods	Rubrics by Kassab[14]; Toulmin-based argumentation scoring [11]	MMAR rubric by[15]; reflective self-assessment [16]
Challenges	Time-consuming; requires structured training; difficulty managing large concept sets	Limited adoption; perceived complexity; need for visualization skills

Table 1 presents a summary of the primary findings derived from the 11 studies included, indicating that concept maps and mind maps are utilized in notably different manners within medical problem-based learning (PBL). The findings suggest that both tools are based on constructivist learning theory; however, their theoretical focus varies, with concept maps aligning more closely with assimilation theory and mind maps linked to radiant thinking. The reviewed studies consistently indicate that concept maps serve primarily as hierarchical tools for the integration of basic and clinical concepts, while mind maps are predominantly utilized for visual summarization and memory enhancement.

The studies indicated a consistent pattern where concept maps were more often linked to enhancements in critical thinking, diagnostic reasoning, and

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meaningful learning. Mind maps have been shown to effectively enhance comprehension, recall, and the organization of ideas. The findings indicated that assessment methods differed between the two tools: concept maps were typically evaluated with structured rubrics, such as those created by Kassab[17], or through argument-based scoring systems, whereas mind maps were assessed using the MMAR rubric or reflective self-assessment questionnaires. The reviewed studies consistently identified challenges associated with both tools. Concept maps are frequently characterized as time-intensive and necessitating structured training, while mind maps have seen limited adoption attributed to perceived complexity and the requirement for visualization skills.

DISCUSSION

A systematic review revealed 128 articles, with 11 fulfilling the eligibility criteria for comprehensive qualitative synthesis. The studies reviewed demonstrate that both concept maps and mind maps offer significant pedagogical benefits in constructivist, student-centered learning contexts in medical education. The studies examined were based on Ausubel's assimilation theory and the broader framework of constructivism, highlighting the importance of meaningful learning through the integration of new information with existing knowledge [18,19]. The literature indicates that concept maps enhance the hierarchical organization of biomedical knowledge, foster reflective learning, and improve clinical reasoning by allowing learners to visualize the relationships among concepts [19–21]. Mind maps serve as a multisensory visual tool that simplifies complex textual content into integrated and memorable representations, thereby enhancing comprehension and long-term recall [5, 18].

A comparative analysis demonstrated distinct functional differences between the two mapping tools. Concept maps highlight a top-down hierarchical organization and the interconnection of concepts, rendering them especially useful for enhancing diagnostic reasoning and problem-solving in problem-based learning sessions [19, 22]. In contrast, mind maps utilize a radial and visually rich format that increases student engagement and creativity, promoting the swift synthesis of new information and enhancing independent learning skills [15, 23]. Despite these advantages, numerous studies have identified practical challenges. Students frequently characterize concept and mind mapping as time-intensive, necessitating particular training and an understanding of visual-organizational strategies [24, 25]. The absence of standardized templates further led to inconsistencies in map quality and interpretation [18].

The results demonstrate that both visual mapping strategies substantially improve the pedagogical effectiveness of project-based learning (PBL). Concept maps are better suited for advanced clinical reasoning and integrative tasks, whereas mind maps are particularly effective for early-stage comprehension, brainstorming, and summarization. This indicates a possible developmental sequence: mind maps may be more suitable for foundational learning in physiology and basic pathological mechanisms, while concept maps may better facilitate higher-level diagnostic and analytical tasks. The evidence reviewed indicates a deficiency in standardized assessment protocols and emphasizes the necessity for dependable, context-specific rubrics that align with the intended learning outcomes. The findings underscore the necessity of thoughtfully integrating visual mapping strategies within PBL curricula to enhance student learning and reasoning outcomes.

CONCLUSION

This systematic review shows that concept maps and mind maps improve Problem-Based Learning in medical education, each serving a different cognitive and pedagogical purpose. Concept maps organize knowledge hierarchically and structure it to facilitate meaningful learning, combine basic and clinical sciences, and support clinical reasoning. Mind maps help summarize, recall, and understand complex content through visual and associative representation.

While useful, both systems face practical problems such time restrictions, controlled training, and student visualization skill variability. The findings emphasize the need for explicit direction, standardized assessment, and curriculum-integrated training to maximize mapping tool educational effectiveness. The implications of sequencing or combining concept maps and mind maps in problem-based learning should be studied to improve medical training results.

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ETHICAL APPROVAL

Ethical approval was not required for this study because it was a systematic review based solely on data from previously published articles and did not involve direct participation of human subjects.

CONFLICTS OF INTEREST

All authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors contributed to the conception and design of the study, literature search, study selection, data extraction, data analysis and interpretation, manuscript drafting, and critical revision of the manuscript. All authors read and approved the final version of the manuscript.

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