Student Perceptions of concept mapping: A Review of current trends

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Abstract
Concept mapping as a learning tool promotes meaningful learning by linking new knowledge to existing cognitive structures. While it is a valuable strategy for retaining information and integrating critical thinking skills, there is a need to understand students' perceptions of this tool. Therefore, a system search was conducted in Scopus and Web of Science databases. The retrieved articles were screened, and data from 10 peer-reviewed articles was synthesized. This review reveals that students found the use of concept mapping a motivating tool for learning, aided interpersonal skills, and collaboration. Furthermore, it also helped with problem-solving, self-directed learning, and higher-order thinking.
Keywords: Concept mapping, student perceptions, meaningful learning, knowledge mapping

Introduction

Concept mapping (CM) is a graphical tool that has gained wide recognition for its utility in organizing and representing knowledge. Concept maps are recognized as a valuable teaching-learning strategy designed to help students retain vast amounts of information and integrate critical thinking skills. It is increasingly being used for various educational purposes by academicians and educators. Beyond traditional paper-based drawings, advancements in information technology, such as touch technologies and computerized tools, have made concept map creation and modification more convenient.

Concept mapping, formally developed by Joseph Novak in the early 1970s, is rooted in David Ausubel's Assimilation Theory of Learning. Ausubel's theory posits that as opposed to rote memorization, learning is most meaningful when new knowledge is integrated with existing knowledge structures. Meaningful learning is when a person consciously and explicitly links new knowledge to relevant concepts or propositions already existing in their cognitive structure. Novak's interpretation of Ausubel's theory emphasizes the hierarchical and relational nature of learning. The mind organizes information hierarchically, and new meanings are acquired through assimilation into existing propositional frameworks. By tying new knowledge to existing cognitive structures, meaningful learning is promoted. This is the basis of the structure of the concept where concepts represented as nodes are linked to each other using linking phrases.

The Structure of a Concept Map

A concept map is a systematic visual representation of knowledge. It is a diagram consisting of concepts placed in nodes that are connected by linking words or phrases. These concepts and linking words together form a proposition, which represents a meaningful statement about the relationship between two concepts.

The map may be arranged in a hierarchical structure, moving from the most general or inclusive concepts at the top down to more specific and detailed concepts. A critical structural element is the cross-link, which forms propositions between concepts residing in different segments or subdomains of the map. Cross-links are vital as they demonstrate relational knowledge and often symbolize the creation of new knowledge or integration of existing ideas. Specific examples can also be added, usually at the lowest level of the map, and are typically not encased in nodes to differentiate them from concepts. Concept mapping, therefore, is a graphical tool that acts as a "visual road map" showing the pathways connecting the meanings of concepts (Novak, 1996).

Methods

A systematic search was conducted in Scopus and Web of Science databases using the search term 'concept map*', 'student', 'perception', 'attitude', 'experience'. The articles were then screened based on inclusion and exclusion criteria, and a total of 10 articles were synthesized in this review.

Study characteristics

Geographical and Disciplinary Landscape

The existing research originates from a broad geographical range, including Nigeria (Okebukola & Jegede, 1989), Trinidad and Tobago (Addae, Wilson, & Carrington, 2012), Taiwan (Hwang, Wu, & Kuo, 2013), India (Joshi &

Vyas, 2018), and Saudi Arabia (Almulla & Alamri, 2021). This breadth suggests widespread recognition of the versatility of creating concept maps

A significant pattern is the focus on Medical and Health Education (Nursing, Epidemiology, Physiology), represented by half of the sources (Addae, Wilson, & Carrington, 2012; Fawaz & Kavuran, 2020; Joshi & Vyas, 2018). This high concentration in medical disciplines is explained by the fundamental challenge of retaining vast amounts of information and the necessity of integrating fragmented concepts across different cognitive compartments, a central utility of CM in medical education (Joshi & Vyas, 2018).

The studies primarily target undergraduate and post-secondary populations, ranging from pre-degree biology students (Okebukola & Jegede, 1989) to first-year university students in Data Science (Liu et al., 2021) and adult learners studying introductory statistics (Trehan, 2015). This indicates that CM is widely investigated as a tool for adult learning and conceptual complexity (Trehan, 2015). The exception is a study on Natural Science that focused on sixth graders in Taiwan, specifically comparing technological modalities (Hwang, Wu, & Kuo, 2013).

Types of Concept Map and Creator Roles

The method of map creation, who produces the map and how, varies significantly across all the studies.

The first type of map is student-centered, i.e., created by students. Most of the quantitative efficacy studies rely on students constructing their own maps, either individually (Trehan, 2015) or in groups (Liu et al., 2021). These maps often aim for hierarchical structure (Okebukola & Jegede, 1989) or may adopt a specialised format like the Spider form when integrated with Problem-Based Learning (PBL) (Addae, Wilson, & Carrington, 2012). The second type is created by instructors. Some studies utilize CM as an instructional strategy prepared by the instructor, where students learn from the maps rather than creating them. This approach was used by Fawaz & Kavuran (2020) in nursing education to deliver maternity health nursing content. Hwang, Wu, and Kuo (2013) also tested a teacher-centered Interactive Whiteboard (IWB)-based approach against student-centered construction.

Technology and Collaboration Trends

The evolution of CM methodology is evident in the increasing integration of technology, particularly to facilitate group work. Addae, Wilson, & Carrington (2012) developed a 5-phase PBL method that specifically incorporates three distinct mapping phases (M1, M2, and M3) into the Problem-Based Learning cycle, utilizing CMAP software. Hwang, Wu, and Kuo (2013) investigated IWB-based and touchscreen-based CM, noting that technology provided an alternative to cumbersome paper-and-pencil methods. The most recent context involves Computer-Supported Collaborative Concept Mapping (CSCCM) using tools like ProcessOn (Liu et al., 2021). This collaborative digital environment facilitates shared awareness and is studied explicitly for its impact on group conceptual knowledge (Liu et al., 2021).

Quality Appraisal

The quality appraisal of the sources was conducted to assess the risk of bias of the included studies. The appraisal draws on the Hawker et al. (2002) criteria with a maximum of 4 points per criterion (for a total maximum score of 36). The appraisal revealed strong performance by most empirical studies, generally scoring between 25 and 34. Studies demonstrated high quality in articulating the abstract & title, introduction & aims, and findings and/or results.

The highest-scoring study (34) was by Trehan (2015), achieved distinction primarily through rigorous measures taken to mitigate ethics and bias. However, systematic weaknesses were identified in sampling and generalizability, frequently scoring low (1 or 2 out of 4) due to reliance on small, localized, or convenience samples. Furthermore, the ethics & bias criteria showed volatility when the investigator served as the instructor (e.g., (Okebukola & Jegede, 1989), (Fawaz & Kavuran, 2020)), presenting a risk of bias. Although internal methodological rigor was high, external applicability is a consistent challenge across some studies.

Thematic analysis and Discussion

The following is a discussion of the findings related to thematic analysis. The themes analysed (see Table 1) are motivation, cognitive skills, interpersonal skills/collaboration, self-directed learning, learning and performance, and problem-solving.

Table 1: Themes covered by each source

Source	**Motivation**	**Cognitive Skills**	**Inter-personal Skills/Collaboration**	**Self-directed Learning**	**Learning and Performance**	**Problem-solving**

(Okebukola & Jegede, 1989)	✓	✓	×	×	✓	×
(Addae, Wilson, & Carrington, 2012)	✓	✓	✓	✓	✓	✓
(Hwang, Wu, & Kuo, 2013)	✓	✓	✓	×	✓	×
(Trehan, 2015)	✓	✓	×	✓	✓	✓
(Joshi & Vyas, 2018)	✓	✓	×	×	✓	✓
(Fawaz & Kavuran, 2020)	✓	✓	×	✓	✓	✓
(Almulla & Alamri, 2021)	✓	✓	✓	✓	✓	✓
Liu et al. (2021)	×	✓	✓	×	✓	×

Motivation

Concept mapping demonstrates a strong positive influence on students' motivation, learning attitudes, and anxiety levels across various disciplines (Okebukola & Jegede, 1989; Joshi & Vyas, 2018; Almulla & Alamri, 2021). Okebukola & Jegede (1989) found a reduction of apprehension associated with difficult subjects that is linked to the deeper understanding provided by student centered concept mapping. Pre-degree biology students who used CM showed a significantly lower level of anxiety towards the topics of genetics and ecology, when compared to their conventionally taught peers (Okebukola & Jegede, 1989). Similarly, medical students reported that the technique was highly useful in boosting their confidence for the subject (Joshi & Vyas, 2018) and nursing students found the CM method to be engaging and motivating towards critical thinking (Fawaz & Kavuran, 2020). Almulla & Alamri (2021) also found that conceptual mapping use was found to increase students' motivation in higher education, thereby enhancing academic achievement.

The use of CM also makes the learning process more enjoyable and engaging (Hwang et al., 2013; Addae et al., 2012). Students were exposed to a modified 5-phase Problem-Based Learning (PBL) method integrated with CM by Addae et al. (2012). Students rated the approach significantly higher in the affective domain (e.g., "made learning fun," "promoted eagerness to learn") compared to a conventional 7-step PBL method.

The integration of technology can amplify motivational gains (Hwang et al., 2013; Almulla & Alamri, 2021). Hwang et al. (2013) found that students who learned using the Interactive Whiteboard (IWB)-based CM approach showed significant improvement in their learning attitudes over students who generated concept maps using paper and pencil. This positive perception is attributed to the enjoyable experiences brought by the touch technologies (Hwang et al., 2013). Conversely, the traditional paper-and-pencil method led to a significant deterioration in students' learning attitudes (Hwang et al., 2013).

Metacognitive Skills

Concept mapping functions explicitly as a metacognitive tool, providing learners with mechanisms to reflect on, monitor, and regulate their own knowledge acquisition (Hwang et al., 2013; Almulla & Alamri, 2021; Fawaz & Kavuran, 2020).This is because, CM facilitates self-evaluation by requiring the learner to externalize their cognitive structure (Trehan, 2015; Almulla & Alamri, 2021; Novak, 1995). The construction process allows students to realise their own knowledge gaps and misconceptions, thereby prompting reflection or further inquiry (Trehan, 2015). Students reported that CM "tickled our critical thinking" and encouraged them to "think deeper about topics" rather than relying merely on memorization (Fawaz & Kavuran, 2020). This enhanced critical thinking is part of CM's power to develop higher-level thinking skills, strategies, and habits (Almulla & Alamri, 2021).

In structured settings, CM significantly supported metacognitive growth (Addae et al., 2012; Almulla & Alamri, 2021). The CM-integrated 5-phase PBL method received significantly higher student ratings in the metacognitive domain, compared to the traditional 7-step method (Addae et al., 2012). This method helps provide a visual representation of thought processes (Addae et al., 2012). Furthermore, collaborative CM nurtures group metacognitive processes by assisting students in maintaining shared awareness during group interactions (Almulla & Alamri, 2021). The visual organization provided by CM also supports mental clarity and control over learning (Novak, 1990; Almulla & Alamri, 2021). By forcing the student to choose precise linking words and relationships, the technique helps clarify misconceptions and integrate fragmented concepts (Trehan, 2015; Fawaz & Kavuran, 2020).

Interpersonal Skills and Collaboration
When applied in group settings, CM and related activities enhance interpersonal skills, foster teamwork, and improve communication among students (Addae et al., 2012; Hwang et al., 2013; Liu et al., 2021; Almulla & Alamri, 2021). Students perceived the CM-integrated 5-phase Problem-Based Learning (PBL) method as significantly promoting interpersonal skills compared to the conventional method (Addae et al., 2012). This domain, which included items on teamwork and positive learning climate, scored significantly higher for the 5-phase approach (Addae et al., 2012). Collaborative efforts are seen as crucial for knowledge construction and improving performance outcomes (Liu et al., 2021; Almulla & Alamri, 2021). Collaborative conceptual mapping and student interaction both showed a direct positive influence on conceptual mapping use itself (Almulla & Alamri, 2021). CM supports interactive learning by providing a mechanism for learners to communicate their thoughts during shared group activities (Almulla & Alamri, 2021).
Liu et al (2021) and Hwang et al. (2013) found that technology fosters these interactions. In Liu et al.'s (2021) study on Computer-Supported Collaborative Concept Mapping (CSCCM), the perception of collaboration among students was found to significantly impact conceptual understanding. Students with a high level of collaboration perception achieved better conceptual knowledge understanding than those with a low level (Liu et al., 2021). The analysis of behavioral patterns confirmed this finding i.e. high collaboration groups exhibited more diverse behavioral transition sequences, indicating efficient information exchange, such as loops involving offering information, leading tasks, and discovering unclear content (Liu et al., 2021). Conversely, low collaboration groups showed fewer and less effective interaction sequences. In Hwang et al.'s (2013) study, they found that students using Interactive Whiteboard (IWB)-based CM enjoyed interactions with the teacher and their peers.

Learning and Performance
Concept mapping is consistently reported across disciplines as an effective method for enhancing meaningful learning, improving conceptual understanding, aiding retention, and boosting academic performance (Okebukola & Jegede, 1989; Joshi & Vyas, 2018; Almulla & Alamri, 2021).
In terms of measurable achievement, a medical education study by Joshi & Vyas (2018) found that the concept map group scored significantly higher in the immediate term-ending exam when compared to the control group. Students strongly perceived that concept mapping was highly useful in memorizing and retaining subject contents and subsequently performing better in exams. The logic is that concept maps create a logical flow of retained information for better understanding which is directly proportional to performance (Joshi & Vyas, 2018).

Concept mapping promotes meaningful learning by enabling the assimilation of new knowledge into existing conceptual frameworks (Okebukola & Jegede, 1989; Almulla & Alamri, 2021). Almulla & Alamri (2021) found that the use of concept maps is related to an increase in students' understanding and motivation to improve their academic achievements. Specifically, this strategy improves knowledge of the topic, promotes retention of knowledge, and enhances long-term memory skills. Computer-Supported Collaborative Concept Mapping (CSCCM) activities, particularly for students with high collaboration perception, yielded better conceptual knowledge understanding (Liu et al., 2021). While concept maps are highly effective, Hwang et al. (2013) found that the type of concept map matters. A student-centered touchscreen-based concept map and a teacher-centered IWB-based approach were more effective in improving learning attitudes (Hwang et al., 2013). On the other hand, a traditional paper-and-pencil method led to a significant deterioration in learning attitudes (Hwang et al., 2013).

Problem-solving
Concept maps support the development of skills necessary for problem-solving, application, and clinical decision-making, though its immediate efficacy in purely procedural application can be mixed (Fawaz & Kavuran, 2020; Trehan, 2015; Almulla & Alamri, 2021). CM is endorsed as a valuable aid in problem-solving by supporting creative thinking and facilitating the exploration of new questions and solutions by Almulla & Alamri (2021). The use of CM was also found to be an important feature in improving decision-making skills for nursing students (Fawaz & Kavuran, 2020). Students reported that the technique enabled them to link patient problems and treatment

modalities to take appropriate theoretical and practical care decisions (Fawaz & Kavuran, 2020). CM therefore contributed to strengthening logical thinking throughout clinical practice, leading to enhanced problem-solving ability (Fawaz & Kavuran, 2020).

In structured learning, the visualization provided by concept maps is essential for applying knowledge to complex situations (Addae et al., 2012). The concept map integrated 5-phase PBL method required students to perform analysis and re-synthesis of clinical presentations to establish clear relationships between features, which are deemed essential skills for clinical practice (Addae et al., 2012). However, the perceived benefit for direct application is not universal. In a study of introductory statistics learners, most participants felt that concept maps did not enhance their ability to apply concepts for problem-solving (Trehan, 2015). This suggests a challenge in translating conceptual organization into procedural, mathematical application (Trehan, 2015). Conversely, those who did find it helpful viewed the map as a guide for solving problems (Trehan, 2015). Even when feeling frustrated, key informants acknowledged that if the map was robust, they could reference it to be reminded of concepts to use for problem-solving (Trehan, 2015).

Conclusion

The studies reviewed collectively highlight a global, predominantly English-speaking academic interest in concept mapping, primarily concentrated within the higher education sectors (Table 1). This confirms the broad scope of applicability of concept maps across diverse disciplines but also demonstrates a bias towards only knowledge constructed in English. Thematic analysis confirms concept mapping's strong positive influence on student motivation, reducing anxiety, and enhancing engagement. Furthermore, concept maps explicitly function as a metacognitive tool, enabling learners to externalize their cognitive structure, identify knowledge gaps, and cultivate higher-level critical thinking skills.

References

Almulla, M. A., & Alamri, M. M. (2021). Using conceptual mapping for learning to affect students' motivation and academic achievement. Sustainability, 13(7), Article 4029. https://doi.org/10.3390/su13074029

Baroody, A. J., & Bartels, B. H. (2000). Using concept maps to link mathematical ideas. Mathematics Teaching in the Middle School, 5(9), 604–609.

Fawaz, M., & Kavuran, E. (2020). Lebanese nursing students' perceptions regarding use of concept mapping. Teaching and Learning in Nursing, 000, 1–5. https://doi.org/10.1016/j.teln.2020.05.003

Hwang, G. J. (2003). A conceptual map model for developing intelligent tutoring systems. Computers & Education, 40(3), 217–235.

Hwang, G.-J., Wu, C.-H., & Kuo, F.-R. (2013). Effects of touch technology-based concept mapping on students' learning attitudes and perceptions. Educational Technology & Society, 16(3), 274–285.

Joshi, U., & Vyas, S. (2018). Assessment of perception and effectiveness of concept mapping in learning epidemiology. Indian Journal of Community Medicine, 43, 37–39. https://doi.org/10.4103/ijcm.IJCM_375_16

Liu, S., Kang, L., Liu, Z., Fang, J., Yang, Z., Sun, J., Wang, M., & Hu, M. (2021). Computer-supported collaborative concept mapping: the impact of students' perceptions of collaboration on their knowledge understanding and behavioral patterns. Interactive Learning Environments. https://doi.org/10.1080/10494820.2021.1927115

Novak, J. D. (1995). Concept mapping: A strategy for organizing knowledge. In S. M. Glynn & R. Duit (Eds.), Learning science in the schools: Research reforming practice (pp. 229–245). Erlbaum.

Novak, J. D. (1996). Concept mapping: A tool for improving science teaching and learning. In D. F. Treagust, R. Duit, & B. J. Fraser (Eds.), Improving teaching and learning in science and mathematics (pp. 32–43). Teachers College Press.

Okebukola, P. A., & Jegede, O. J. (1989). Students' anxiety towards and perception of difficulty of some biological concepts under the concept-mapping heuristic. Research in Science & Technological Education, 7(1), 85–92. https://doi.org/10.1080/0263514890070109

Schroeder, N. L., Nesbit, J. C., Anguiano, C. J., & Adesope, O. O. (2017). Studying and constructing concept maps: a meta-analysis. Educational Psychology Review. https://doi.org/10.1007/s10648-017-9403-9

Trehan, D. M. (2015). The impact of concept mapping as a learning tool on student perceptions of and experiences with introductory statistics [Unpublished doctoral dissertation]. Kent State University.