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AI-supported citation mapping for evidence retrieval in dental education: a controlled study in dental students.

Mapeo de citas asistido por inteligencia artificial para la búsqueda de evidencia en educación odontológica: estudio controlado en estudiantes de odontología.

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Abstract.
Artificial intelligence (AI) tools can support the search and organization of scientific literature in dental education, particularly during the development of systematic reviews. This study evaluated the impact of Litmaps, an AI-supported citation mapping tool, on the performance of dental students during systematic literature review exercises. A pilot controlled educational intervention with two parallel groups was conducted. The experimental design was conducted with 30 students, divided into an experimental group (using the AI-based tool) and the control group (conventional search). The variables measured included the number of articles identified, time spent searching, quality of the reviews and students' perceptions through pre/post questionnaire application. The experimental group identified more relevant articles than the control group (17.8 ± 3.6 vs. 12.4 ± 4.2; $p < 0.05$) and spent less time on the search process (9.6 ± 2.5 h vs. 14.3 ± 3.1 h; $p < 0.01$). No significant differences were observed in review quality (16.2 ± 1.1 vs. 15.9 ± 1.3; $p = 0.56$). Most students evaluated the AI-supported citation mapping tool positively, although one-third acknowledged excessive reliance on it. The use of the AI-supported citation mapping tool improved the efficiency of literature searches without affecting the quality of analysis, highlighting its potential as a support resource in teaching scientific methodology, provided it is accompanied by critical and reflective guidance.

Keywords*:* Dental Education, Evidence-Based Dentistry, Educational Technology, Information Literacy, Litmaps.

Resumen.
Las herramientas de inteligencia artificial (IA) pueden apoyar la búsqueda y organización de literatura científica en educación odontológica, particularmente durante el desarrollo de revisiones sistemáticas. Este estudio evaluó el impacto de Litmaps, una herramienta de mapeo de citas asistida por inteligencia artificial, en el desempeño de estudiantes de odontología durante ejercicios de revisión sistemática de la literatura. El diseño experimental incluyó a 30 estudiantes, distribuidos en un grupo experimental, que utilizó la herramienta basada en IA, y un grupo control, que realizó una búsqueda convencional. Las variables evaluadas incluyeron el número de artículos identificados, el tiempo dedicado a la búsqueda, la calidad de las revisiones y las percepciones de los estudiantes mediante la aplicación de cuestionarios pre y postintervención. El grupo

experimental identificó más artículos relevantes que el grupo control (17.8 ± 3.6 vs. 12.4 ± 4.2; $p < 0.05$) y dedicó menos tiempo al proceso de búsqueda (9.6 ± 2.5 h vs. 14.3 ± 3.1 h; $p < 0.01$). No se observaron diferencias significativas en la calidad de las revisiones (16.2 ± 1.1 vs. 15.9 ± 1.3; $p = 0.56$). La mayoría de los estudiantes evaluó positivamente la herramienta de mapeo de citas asistida por IA, aunque una tercera parte reconoció una dependencia excesiva de su uso. El uso de una herramienta de mapeo de citas asistida por IA mejoró la eficiencia de las búsquedas bibliográficas sin afectar la calidad del análisis, lo que destaca su potencial como recurso de apoyo en la enseñanza de la metodología científica, siempre que se acompañe de una orientación crítica y reflexiva.

Palabras clave: Educación Odontológica, Odontología Basada en Evidencia, Tecnología Educativa, Alfabetización Informacional, Litmaps.

1. Introduction

Systematic literature reviews (SLRs) are considered the gold standard of scientific evidence and play a crucial role in health sciences by guiding the decision-making on the available clinical evidence (1). SLRs gather and critically analyze the relevant findings from multiple primary studies in a clear and reproducible manner, offering robust conclusions for clinical practice implications. However, leading high-quality SLRs presents significant methodological challenges such as search strategies in databases, consistent application of inclusion/exclusion criteria and critical appraisal of bias and study quality.

In the case of undergraduate students in training, the fact that many professors are unable to carry research projects to completion makes the process even more challenging for learners, often leading to frustration. As a result, academic work tends to show methodological flaws and biased interpretations. Several factors contribute to this challenge, including limited methodological training, difficulty accessing reliable literature, journal access costs, and the limited time students can realistically devote to research. Added to these, there are a lack of adequate supervision, scarce institutional incentives, and a weak culture of research. All these conditions create a vicious cycle in which neither professors nor students develop solid research skills, ultimately diminishing the quality and impact of scholarly production (2).

Numerous studies have revealed a frequent inadequacy in published SLRs, such as poor transparency and reproducibility in reporting search strategies (3). These methodological concerns can compromise the acceptability of reviews and the clinical recommendations derived from them.

In parallel, the rapid evolution of artificial intelligence (AI) is opening new avenues in both education and research. In recent years, educators have begun integrating AI tools into higher education to enhance learning experiences and innovate pedagogical processes (4) in medical and dental education, the potential of advanced digital technologies to improve both theoretical and practical training is increasingly acknowledged, preparing students for more evidence-informed clinical practice. Specifically, the rise of generative AI models (such as large language models like ChatGPT, OpenAI, San Francisco, CA, USA) has sparked broad interest in educational research. These tools can understand and generate natural language, enabling their use for tasks such as personalized feedback, simulated clinical case generation, and support in academic writing (5).

AI-based tools can support different stages of literature reviews. For example, ChatGPT may help summarize articles or answer questions from selected texts, while platforms such as Iris.ai can assist with cross-analysis and synthesis of scientific information (6). Automated systems like RobotReviewer have even been developed to assess risk of bias in clinical trials (7). The integration of these tools raises ethical and methodological concerns: how should authorship and

accountability be defined when AI makes a substantial contribution to an academic product? In response, experts have advocated for clear guidelines on AI usage in research, recommending that authors explicitly report when and how AI tools are used. Continuous human oversight and validation of AI-generated outputs is also critical. A balanced approach is essential: while automation can save time and optimize routine tasks, AI tools do not replicate human qualities such as creativity, expert judgment, or pedagogical empathy (8). Recent studies emphasize that optimal AI integration in higher education requires a balance between technological innovation, educational effectiveness and ethics, ensuring that AI complements—rather than replaces—the intellectual work of both teachers and students (9).

In the field of dentistry, AI applications have thus far focused primarily on clinical uses—for example, in image analysis for radiographic diagnosis, caries detection, or treatment planning (10). This strong clinical orientation contrasts with the scarcity of documented experiences involving AI-based tools in academic research tasks such as literature search and review. Given that dental education includes the development of research competencies, it is pertinent to explore how AI tools might be employed didactically to enhance these skills.

From a pedagogical perspective, citation mapping tools may be relevant in dental education because they support evidence retrieval while helping students visualize relationships among studies within a research field (11). This visual and network-based approach may strengthen information literacy, search planning, and metacognitive monitoring during early research training (12-13). However, their educational value should not be assessed only by efficiency indicators, such as time reduction or number of retrieved articles, but also by whether students preserve critical appraisal, methodological rigor, and independent judgment when selecting and interpreting evidence (14-15).

In this context, the present study aimed to implement a didactic intervention incorporating the AI-supported citation mapping tool (Litmaps, www.litmaps.com, Customhouse Quay, Wellington, New Zealand) to support dental students in conducting systematic literature reviews. The study hypothesizes that first-year dental students using the AI-based citation mapping tool will improve their literature search efficiency and review performance compared with students using conventional manual search methods, by identifying more relevant articles in less time while maintaining comparable quality in their systematic review exercises.

2. Methods

Study design and setting

This study was a pilot controlled educational intervention with two parallel groups conducted during the Problem-Based Learning (PBL) subject in November 2025. The study compared an AI-supported citation mapping strategy with conventional manual database searching for the development of systematic literature review exercises. A total of 30 first-year dental students voluntarily participated; they were randomly allocated in a 1:1 ratio using a random number table generated from an anonymized participant list to either the experimental group (n = 15) or the control group (n = 15), with comparable demographic and academic characteristics, while students who did not complete the search activity, questionnaire, or review assignment were excluded from the final analysis.

Educational intervention

Students in the experimental group received an initial 2-hour training session on the use of the AI-based tool. Litmaps uses AI-supported citation mapping to identify related publications from a topic or "seed" article and display them as visual research maps. This approach may help students recognize key studies, understand connections within a research field, and identify relevant

literature that could be missed through conventional searches (11). Litmaps was used as an AI-supported citation mapping platform based on citation-network exploration. According to the platform documentation, its database integrates bibliographic and citation metadata mainly from Semantic Scholar, OpenAlex, and Crossref. In contrast, the conventional search group used structured manual searching in PubMed/MEDLINE with Boolean operators and MeSH terms. Therefore, the intervention compared a citation-network discovery strategy against a controlled vocabulary-based database search strategy. Students were instructed that records identified through Litmaps should be verified in bibliographic databases or citation indexes before final inclusion. Therefore, this study evaluates whether guided use of Litmaps improves search efficiency and literature analysis compared with traditional methods, while also exploring students' perceptions of its usefulness and limitations. The training included a demonstration of its features (searching for articles based on a given article, expanding citation networks, filtering results, and visualizing literature maps), as well as best practices for incorporating it into bibliographic searches. Each student was subsequently tasked with conducting a systematic literature review on a dental topic relevant to the curriculum "Biosafety in Dentistry".

A PICO question, along with clearly defined inclusion and exclusion criteria, was established under the guidance of the instructor: *In dental professionals and students, does the implementation of enhanced biosafety protocols compared to conventional practices reduce the incidence of cross-infections and exposure to pathogens in clinical settings? P (Population):* Dental professionals and students, *I (Intervention):* Implementation of enhanced biosafety protocols, *C (Comparison):* Conventional practices, *O (Outcome):* Reduction in the incidence of cross-infections and exposure to pathogens.

For the experimental group, seed articles were selected using predefined criteria. Students first performed an initial keyword search related to biosafety in dentistry and selected one to three seed articles that met the following conditions: direct relevance to the PICO question, publication in a peer-reviewed journal, availability of complete bibliographic metadata, and clear focus on biosafety protocols, cross-infection prevention, or occupational exposure in dental settings. The instructor supervised this initial selection to ensure that the seed articles were appropriate starting points for citation mapping and comparable across students.

During the search phase, the experimental group could input one or more known key articles on the topic to generate literature maps and discover related papers through citation connections. The control group was taught to conduct manual searches using Boolean connectors (AND, NOT, OR) and MeSH (Medical Subject Headings) terms in bibliographic databases such as PubMed. Reference tracking and manual article selection were also included. Both groups were given two weeks to complete the review (search and selection stages).

A structured online questionnaire (written in Spanish) was developed by the authors using Google Forms survey (https://forms.gle/XfiXXCBgV7CfoAdL8). The purposes of this educational intervention and was not intended as a validated psychometric instrument. It was used to collect descriptive information on students' search experiences, perceived usefulness, time investment and perceived risk of overreliance. The questionnaire was administered before and after the didactic intervention to compare students' experiences between the experimental and control groups. The pre-intervention questionnaire collected baseline data on age, sex, most recent academic activity completed, databases used for information searching, perceived difficulty in conducting literature searches, perceived ease of use of the platform, average number of articles or abstracts reviewed, understanding of the topic based on retrieved information, time invested in the academic activity, and previous knowledge or use of AI-based tools applied to scientific literature searching, excluding general-purpose chatbots such as ChatGPT or Bard. Following the two-week intervention period, the same questionnaire was re-administered to collect post-intervention data and evaluate

changes in students' search experience, perceived usefulness, time investment, and interaction with AI-supported literature search tools. Briefly, the primary outcome corresponded to time spent on the literature search process and the secondary outcome, the number of relevant articles identified, reviewed quality score, calendar time to complete the activity, and student perceptions (table 1).

Table 1. Design of the didactic intervention.

Component	AI-supported group	Control group
Initial training	2-hour Litmaps session	2-hour manual search session
Search strategy	Citation mapping and network expansion	Boolean operators and MeSH terms
Topic	Biosafety in dentistry	Biosafety in dentistry
PICO	Same standardised PICO	Same standardised PICO
Timeframe	2 weeks	2 weeks
Output	Review exercise	Review exercise

Review quality was assessed using a standardized educational rubric developed for this activity. The rubric evaluated five domains: clarity of the PICO question, adequacy of the search strategy, consistency in the application of inclusion and exclusion criteria, organization and synthesis of the selected evidence, and critical interpretation of the findings. Each domain was scored on a structured scale, generating a total review quality score. The rubric was applied uniformly to both groups. To reduce assessment bias, reviews were evaluated using the same criteria and without considering the number of articles retrieved as an independent indicator of quality.

Data analysis

Data were analysed using descriptive and comparative statistics by means and standard deviations were calculated for quantitative variables. The data were analysed by non-parametric Mann-Whitney U test with a significance level of $\alpha = 0.05$. In case of proportions were analysed using χ^2 tests. Qualitative comments from the survey were subjected to basic content analysis to identify recurring themes or patterns in student opinions. All statistical processing was performed using SPSS v25.0.

Ethical considerations

This study was conducted in accordance with institutional ethical standards for educational research and the principles of the Declaration of Helsinki. Participation was voluntary and anonymous, and all students were informed about the purpose of the study. Students were also informed that participation or non-participation would have no academic consequences. Informed consent was obtained from all participants before data collection. The study was conducted as part of an anonymous educational improvement activity and was classified as minimal risk by the academic coordination of the course.

Bias control

To reduce performance bias, both groups received a 2-hour training session and worked on the same PICO question, inclusion/exclusion criteria, topic and timeframe. To reduce selection bias, participants were randomly allocated in a 1:1 ratio from an anonymised participant list. To reduce information bias, the same questionnaire and review-quality rubric were applied to both groups. Potential contamination between groups, self-reported time estimates and lack of blinding during review assessment were recognised as possible sources of bias.

3. Results

Table 2 summarizes the main quantitative outcomes of the educational intervention. Students in the AI-supported citation mapping group identified more relevant articles and spent less time on the search process than students in the conventional search group, while no significant differences were observed in review quality.

Table 2. Comparison of search performance and review quality between groups.

Outcome	AI-supported citation mapping group	Conventional search group	p-value
Relevant articles identified	17.8 ± 3.6	12.4 ± 4.2	<0.05
Time spent on search process, h	9.6 ± 2.5	14.3 ± 3.1	<0.01
Calendar time to complete search phase, days	8	12	<0.01
Review quality score	16.2 ± 1.1	15.9 ± 1.3	0.56

Values are expressed as mean ± standard deviation unless otherwise indicated. Comparisons between groups were performed using the Mann–Whitney U test for quantitative variables and χ^2 test for proportions.

Number of included articles

The experimental group identified a significantly higher number of relevant articles than the control group (17.8 ± 3.6 vs 12.4 ± 4.2; $p < 0.05$). This finding suggests that the AI-supported citation mapping strategy facilitated broader retrieval of potentially relevant literature. However, this result should be interpreted as an improvement in search efficiency and coverage, rather than as direct evidence of superior review quality.

Time spent on the search process

In terms of time invested, the experimental group demonstrated greater significantly efficiency spent time an average of 9.6 ± 2.5 hours vs. 14.3 ± 3.1 hours ($p < 0.01$) on the search, screening, and article selection process, while those in the control group spent. Besides, the total calendar time to complete the search phase was significantly shorter ($p < 0.01$) for the experimental group, with an average of 8 days compared to 12 days in the control group.

Review quality

When evaluating the overall quality both groups obtained comparable results of the academic reviews with a standardised rubric. The experimental (16.2 ± 1.1) and control group (15.9 ± 1.3) did not show statistically significant difference ($p > 0.05$). These findings indicate that although the AI-supported citation mapping tool enhanced the efficiency of literature searching, it did not significantly improve the quality of the submitted reviews.

Student perceptions of the AI-supported citation mapping tool

The survey results showed a high level of student acceptance of the AI-based tool. Overall, 85% of students in the experimental group (13 out of 15) reported that the platform helped them identify key articles more easily. In addition, 75% indicated that the network visualization map improved their understanding of the research landscape by helping them recognize connections among major studies (figure 1). Approximately two-thirds of the students (68%) stated that they would recommend using the AI-based tool in future research methodology assignments. However,

nearly one-third (32%) acknowledged that they may have relied too heavily on the platform's automated suggestions, which could have reduced their initiative to perform manual searches. This finding highlights a potential risk of technological overdependence and reinforces the importance of providing clear academic guidance when integrating AI-supported tools into dental education.

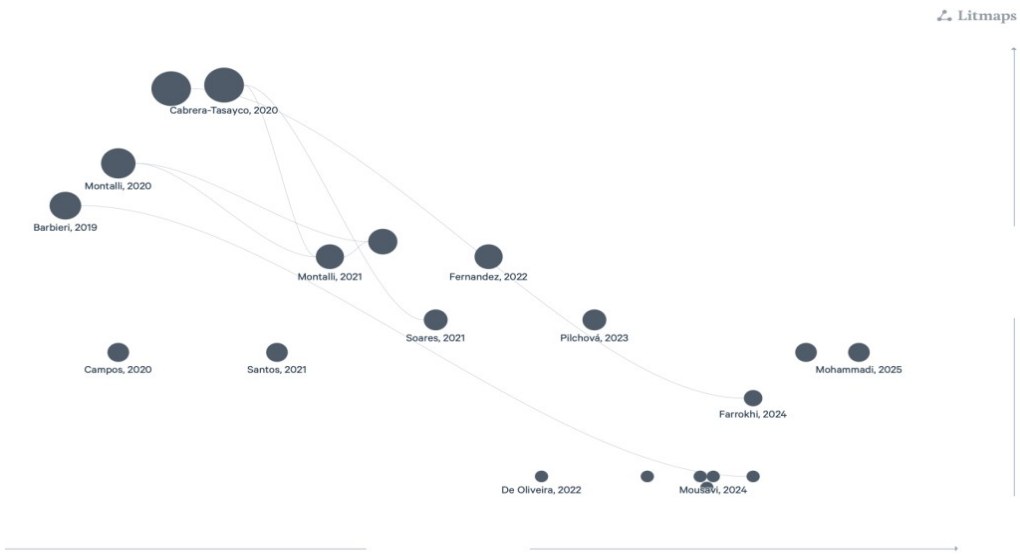

Figure 1. AI-supported citation mapping of the research landscape in biosafety in dentistry.

Experience of the control group

In case of the students in the control group, often described the process as tedious and frustrating. More than half (58%) expressed uncertainty about whether they had identified all relevant articles, noting that the absence of technological support made the task both time-consuming and inefficient. Feelings of doubt were common, with several participants voicing concern that key publications might have been missed despite their efforts. The frustration reported by students in the control group should not be interpreted only as a negative perception of manual searching, but also as an indicator of the cognitive load associated with traditional evidence retrieval in novice learners. Manual searching remains essential for developing information literacy; however, students may require more structured support, examples of search strings, guided practice with MeSH terms, and feedback during the screening process. Future educational designs could combine manual searching with AI-supported citation mapping, allowing students to first learn reproducible database strategies and then use citation networks as a complementary method for expanding and validating the search.

4. Discussion

The results of this didactic intervention suggest that integrating an AI-supported citation mapping tool can enhance the information retrieval phase in systematic literature reviews conducted by undergraduate dental students compared to traditional methods. The use of AI-based tool enabled students to identify a greater number of relevant articles more efficiently. This finding aligns with recent literature highlighting the emerging role of AI in supporting academic processes (12).

The AI-supported citation mapping tool showed associations among publications through citation networks enhanced students' comprehension of the research domain and broader thematic

coverage. This characteristic is mainly relevant in dentistry, where systematic reviews are a cornerstone of evidence-based clinical decision-making (1).

A key finding of this study was the dissociation between search efficiency and review quality. Students using Litmaps identified more relevant articles and completed the search process in less time; however, the review quality score did not differ significantly between groups. This suggests that AI-supported citation mapping may optimize the retrieval and organization of literature, but it does not automatically improve higher-order cognitive processes such as critical appraisal, synthesis, methodological judgment, or interpretation of evidence. In educational terms, the tool appears to support the mechanical and exploratory stages of evidence retrieval, whereas the quality of the final review remains dependent on students' methodological training, critical thinking, and instructor guidance.

The absence of significant differences in review quality may also reflect the nature of the competencies evaluated by the rubric. While citation mapping can help students locate and visualize relevant literature, review quality requires more complex cognitive skills, including the ability to justify inclusion decisions, compare study designs, identify methodological limitations, and synthesize findings coherently. These skills are unlikely to improve after a short intervention if they are not explicitly taught and practiced. Therefore, Litmaps should be understood as a scaffolding tool for evidence retrieval rather than as an independent mechanism for improving scientific reasoning. This interpretation is consistent with recent evidence showing that AI-supported educational outputs may reduce time and effort, but still require expert review, contextual adaptation, and pedagogical supervision before being used for educational purposes (17).

The study showed that no statistically significant differences were identified in case of review quality of the articles between the groups, indicating that AI-assisted searches did not diminish students' critical thinking or synthesis skills. These results are in line with prior work on critical literacy analysis (13). AI-based tools are a complement rather than a substitute for human cognitive processes.

The qualitative responses also revealed an important educational tension. On the one hand, students perceived Litmaps as useful because it reduced uncertainty, accelerated article discovery, and provided a visual overview of the research landscape. This positive perception is consistent with recent evidence showing favorable attitudes and interest among health sciences students toward the incorporation of AI in education, although ethical and pedagogical challenges remain (18). Rather, approximately one-third of participants acknowledged excessive reliance on the platform's automated suggestions. This finding is pedagogically relevant because efficiency gains may be accompanied by a risk of passive searching, reduced exploration of controlled vocabularies, and limited verification of retrieved records. Consequently, AI-supported mapping should be integrated with explicit instruction on database searching, citation verification, source appraisal, and transparent reporting of search decisions.

Qualitative responses from the post-intervention survey variables indicated that overall positive perceptions of the AI-supported citation mapping tool emphasizing its ease use and value in identifying relevant literature. Nevertheless, a recurring concern was technological dependence, as some participants reported relying exclusively on the system's suggestions rather than engaging in manual searching. This pattern was previously reported in the literature as the risk of "uncritical use" of AI in higher education (14), which may hinder the development of evaluative skills without appropriate instructional support.

From an educational perspective, instructors have an essential role in guiding students on how to use these technologies responsibly and critically, rather than relying on them passively. Their guidance can help students develop metacognitive, evaluative, and ethical skills when working with AI-supported tools. At the institutional level, clear guidelines for the academic use of AI are also needed to promote transparency, responsible practices, and better integration of these tools in dental education (15, 19).

This study presents several limitations, the first was related to the small sample size, second, time on task was self-reported, which may introduce perception bias. Third, review quality assessment was based on a rubric developed for this educational activity and may be subject to evaluator bias, particularly if assessment was not blinded to group allocation. Fourth, possible contamination between groups cannot be excluded because students belonged to the same academic setting (16). Finally, the study did not evaluate the long-term effect of AI-supported citation mapping on research skills, critical appraisal or independent literature searching.

5. Conclusions

- The integration of Litmaps, as an AI-supported citation mapping tool, improved literature search efficiency among dental students by increasing the number of relevant articles identified and reducing the time required for evidence retrieval.
- However, the absence of significant differences in review quality indicates that AI-supported tools mainly facilitate the search and organization stages, while critical appraisal and synthesis remain dependent on students' methodological training and academic supervision.
- Therefore, Litmaps should be used as a complementary educational resource rather than as a substitute for structured database searching, critical judgment, or instructor guidance.
- Articles identified through citation mapping should be verified in specialized databases and citation indexes to ensure academic quality, metadata accuracy, and methodological rigor. Its use in dental education should be accompanied by explicit guidance on responsible AI use, information literacy, and avoidance of technological overdependence.

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Declaration on the use of artificial intelligence: Litmaps was the AI-supported citation mapping tool evaluated in the educational intervention. Any AI-assisted language support used during manuscript preparation was limited to editing for clarity and did not replace authorial judgment, data analysis, or interpretation. All authors reviewed and approved the final content.
Data availability: The anonymized dataset, questionnaire, and review-quality rubric are available from the corresponding author upon reasonable request.

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