Revista Española
de Educación Médica

UNIVERSIDAD DE MURCIA

Vibe-coding as a Teaching Competency in the Use of Artificial Intelligence for Medical Education: A Scoping Review.

Vibe-coding como competencia docente en el uso de Inteligencia Artificial para la Educación Médica: una revisión de alcance.

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Received: 3/3/26; Accepted: 16/3/26; Published: 18/3/26

Abstract.

Introduction: The emergence of Generative Artificial Intelligence has given rise to vibe-coding, a paradigm that allows educators without technical backgrounds to develop software using natural language. This advancement necessitates redefining the teaching competencies required to transition from users to creators of educational tools. **Methods**: A scoping review of the literature was conducted following PRISMA-ScR guidelines. Studies retrieved from Web of Science and Scopus databases addressing the use of vibe-coding by educators in higher and medical education were included. After the selection process, four publications from 2025 were included. A deductive reflexive thematic analysis was applied to classify findings according to the TPACK model dimensions (Technological, Pedagogical, and Content Knowledge). **Results**: Qualitative analysis reveals a reconfiguration of Technological Knowledge (TK), which dissociates from programming syntax to focus on structuring prompts and iterative dialogue with AI. The emergence of the "clinician-developer" role was identified, where Content Knowledge (CK) acts as an indispensable auditing mechanism to validate clinical accuracy and prevent hallucinations in generated algorithms. Technological-Pedagogical Knowledge (TPK) enabled educators to deconstruct complex logic into sequential steps to design simulators and personalized tools. **Conclusions**: Preliminary evidence suggests that vibe-coding democratizes educational software development, allowing educators to materialize complex pedagogical strategies without external technical dependence. This competency appears to demand robust disciplinary mastery to guarantee the safety and quality of the created resources. It is recommended to foster training in this emerging competency and conduct future empirical studies to evaluate the impact of these tools on student learning and teacher cognitive load.

Keywords: Vibe-coding, Simulators, Generative Artificial Intelligence, Medical Education, Teacher Competence, TPACK, AI-assisted programming.

Resumen.

Introducción: La irrupción de la Inteligencia Artificial Generativa ha dado lugar al vibe-coding, un paradigma que permite a educadores sin formación técnica desarrollar software mediante lenguaje natural. Este avance plantea la necesidad de redefinir las competencias docentes necesarias para transitar de usuarios a creadores de herramientas educativas. **Métodos**: Se realizó una revisión de alcance de la literatura conforme a los lineamientos PRISMA-ScR. Se incluyeron estudios recuperados de las bases de datos Web of Science y Scopus que abordaran el uso del vibe-coding por parte de docentes en educación superior y médica. Tras el proceso de selección, se incluyeron 4 publicaciones de 2025. Se aplicó un análisis temático reflexivo deductivo para clasificar los hallazgos según las dimensiones del modelo TPACK (Conocimiento Tecnológico, Pedagógico y del Contenido). **Resultados**: El análisis cualitativo revela una reconfiguración del Conocimiento Tecnológico (TK), el cual se disocia de la sintaxis de programación para centrarse en la estructuración de prompts y el diálogo iterativo con la IA. Se identificó la emergencia del rol de "clínico-desarrollador", donde el Conocimiento del Contenido (CK) actúa como un mecanismo de auditoría indispensable para validar la precisión clínica y evitar alucinaciones en los algoritmos generados. El Conocimiento Tecnológico-Pedagógico (TPK) permitió a los docentes deconstruir lógicas complejas en pasos secuenciales para diseñar simuladores y herramientas personalizadas. **Conclusiones**: Evidencia preliminar sugiere que el vibe-coding democratiza el desarrollo de software educativo, permitiendo a los docentes materializar estrategias pedagógicas complejas sin dependencia técnica externa. Esta competencia emergente parece exigir un dominio disciplinar robusto para garantizar la seguridad y calidad de los recursos creados. Se recomienda fomentar la capacitación en esta competencia emergente y desarrollar futuros estudios empíricos que evalúen el impacto de estas herramientas en el aprendizaje estudiantil y la carga cognitiva docente.

Palabras clave: Vibe-coding, Simuladores, Inteligencia Artificial Generativa, Educación Médica, Competencia docente, T-PACK, programación asistida por inteligencia artificial.

1. Introduction

The emergence of Generative Artificial Intelligence (GAI) in education is transforming teaching roles, pedagogical practices, and professional competency frameworks. The effective integration of GAI requires educators to develop technical and pedagogical competencies, with particular attention to equity and adaptability in the face of rapid technological evolution (1-3). The need for robust competency frameworks is fundamental to ensuring the responsible adoption of GAI in diverse educational contexts.

Vibe coding is a novel approach to AI-assisted software development that enables individuals without technical expertise, such as medical educators or clinicians, to create applications, simulations, and interactive learning tools using simply natural language. It is defined as a "human-in-the-loop" approach. It is not a single instruction but rather a dialogue. The educator uses conversational "prompts." The process typically involves multiple rounds of refinement in which the educator tests the tool, identifies errors, and asks the AI to correct them or adjust the design.

This approach represents an emerging trend with potentially transformative implications: it enables educators to move from being mere technology "adopters" (using what others build) to becoming active "creators." Subject matter experts (such as physicians) can build customized tools for their specific teaching needs without relying on professional software developers, dramatically reducing development costs and time.

1.1 Teaching Competencies in the Use of AI.

To effectively integrate generative artificial intelligence into teaching, educators must develop a combination of technical and pedagogical competencies: solid AI literacy (including prompt engineering), ethical reasoning, a focus on inclusion, continuous professional learning, and strategies for overcoming infrastructure and digital literacy gaps. Success depends on structured professional training, clear ethical frameworks, and supportive institutional policies (4-7, 31).

1.2 The TPACK Model for Understanding Teaching Competencies in AI Use.

Among the frameworks that have emerged to guide the development of teaching competencies in GAI, one of particular relevance is the TPACK (Technological Pedagogical Content Knowledge) model. This model enables the analysis of technology integration in teaching from a holistic perspective, considering the interaction among technological, pedagogical, and content knowledge. It consists of three main domains and their intersections (8-9).

The domains are:

- Technological Knowledge (TK): Mastery of technological tools and systems, including generative AI.
- Pedagogical Knowledge (PK): Effective teaching strategies and methods.
- Content Knowledge (CK): Specific disciplinary mastery.

The intersections of these domains are:

- TPK (Technological-Pedagogical): How technology transforms pedagogy.
- TCK (Technological Content): How technology mediates the access to and representation of content (10).
- PCK (Pedagogical Content): How pedagogy mediates content learning.
- TPACK (Integrated): Dynamic synthesis of all three domains for designing innovative learning experiences.

1.3 Key Intersections: TPK and TCK in the Design of Activities with GAI.

The application of the TPACK model to the GAI context facilitates the identification of key competencies, the detection of training gaps, and the design of professional development strategies aligned with the contextual challenges of AI (11, 32).

Specifically, TPK enables educators to understand how GAI can transform interaction, feedback, and the personalization of learning. TCK facilitates the selection of GAI tools that represent and explore disciplinary content in innovative ways (e.g., simulations in sciences, text generation in languages) (12). TCK tends to have a slightly greater impact on the overall development of TPACK, especially in STEM areas, but the synergy with TPK is essential for pedagogical innovation (9).

To address the specific challenges and opportunities of AI, models such as Intelligent-TPACK and AI-TPACK have emerged, which extend the traditional framework by incorporating AI-specific knowledge (11, 13-15). Unlike the original model, the Intelligent-TPACK incorporates ethical decision-making (privacy, bias, transparency, accountability) as a cross-cutting and progressive component, clearly differentiating between the competencies of human educators and AI systems. The advantages of this evolution include better alignment with current AI challenges, the integration of ethics at all stages of digital literacy, and greater precision in human-machine collaboration.

1.4 Vibe-coding as a New Teaching Competency.

Vibe-coding is an emerging paradigm of software development that enables non-programmer users to create interactive applications and prototypes through the use of natural language and Generative Artificial Intelligence (GAI) systems. Its direct antecedent is computer-assisted programming, originally known as low-code or no-code assisted programming (16). However, with the emergence of GAI, this approach has transcended its initial limits, acquiring much broader operational dimensions.

The relevance of this paradigm lies in the democratization of access to software development. This openness allows educators, clinicians, and other professionals without technical training to materialize their digital ideas, overcoming the shortage of programming skills that traditionally represented a significant barrier (17-20). To ensure the success of this process, it is essential to master effective prompt engineering techniques, promote user training in these methods, and have debugging and feedback tools available to mitigate potential errors in the generated code.

1.5 Justification and Objective of the Study.

Despite the growing impact of Generative Artificial Intelligence in education, there is a gap in the literature regarding the theoretical conceptualization of its new pedagogical applications. To date, no studies have been identified that integrate vibe-coding as a teaching competency under the theoretical framework of the TPACK model. Therefore, the present study aims to analyze vibe-coding as an emerging teaching competency for the use of Generative Artificial Intelligence, providing a reference framework for its effective integration into educational practice.

2. Methods

The present study was developed through a systematic literature review based on PRISMA-ScR guidelines (21-22). This methodological approach was selected given the emerging nature of the phenomenon and the need to map the available evidence rather than synthesize outcomes from a consolidated body of literature. The objective was to identify scientific publications and case studies addressing the use of vibe-coding by educators in higher education. Based on the analysis of these records, the teaching competencies developed through this paradigm were described, with particular emphasis on findings relevant to the context of Medical Education. It should be noted that, given the nascent state of this field, the search encompassed studies on vibe-coding in education broadly; however, the thematic analysis prioritized the identification and discussion of competencies applicable to medical education settings.

The bibliographic search was carried out in the Scopus and Web of Science databases. To ensure comprehensiveness, the same search strategy using identical search terms was also applied in PubMed, ERIC, CINAHL, and Google Scholar; however, these additional searches did not yield publications beyond those already identified in Scopus and Web of Science, and were therefore not included in the description of the selection process. This outcome is consistent with the extremely recent emergence of vibe-coding as a documented practice.

Initially, the following main search string was established: ALL= (“vibe-coding” OR “vibe coding”) AND (“teacher*” OR “educator*” OR “faculty” OR “lecturer*” OR “higher education”). To ensure the comprehensiveness of the review, a second iteration was executed expanding the technical terms associated with the phenomenon: (“vibe-coding” OR “vibe coding” OR “no-code programming” OR “low-code programming” OR “natural language programming” OR “conversational programming”) AND (“teacher*” OR “educator*” OR “faculty” OR “lecturer*” OR “higher education”). It should be noted that this conceptual expansion did not yield additional articles that met the established inclusion criteria.

The application of this search strategy resulted in the initial identification of 10 records: 4 from Scopus and 6 from Web of Science. After the selection and filtering process, the final sample consisted of 4 publications directly related to the practice of vibe-coding in the educational field (figure 1 and table 1).

2.1 Data Analysis.

Once the articles were identified through the systematic review, they were examined by applying a reflexive thematic analysis, grounded in the phases proposed by Braun and Clarke (23-25). Although reflexive thematic analysis is frequently associated with inductive approaches, Braun and Clarke (25) explicitly acknowledge its compatibility with deductive orientations, where theoretical frameworks guide the analytical lens. In this study, a deductive procedure was adopted: the TPACK model dimensions were established a priori as the organizing framework for the analysis, while maintaining a reflexive stance toward the data. This means that, although the overarching categories (TK, PK, CK, TPK, TCK, PCK) were predetermined, the specific codes and sub-themes within each dimension emerged through iterative engagement with the texts, preserving the reflexive character of the approach.

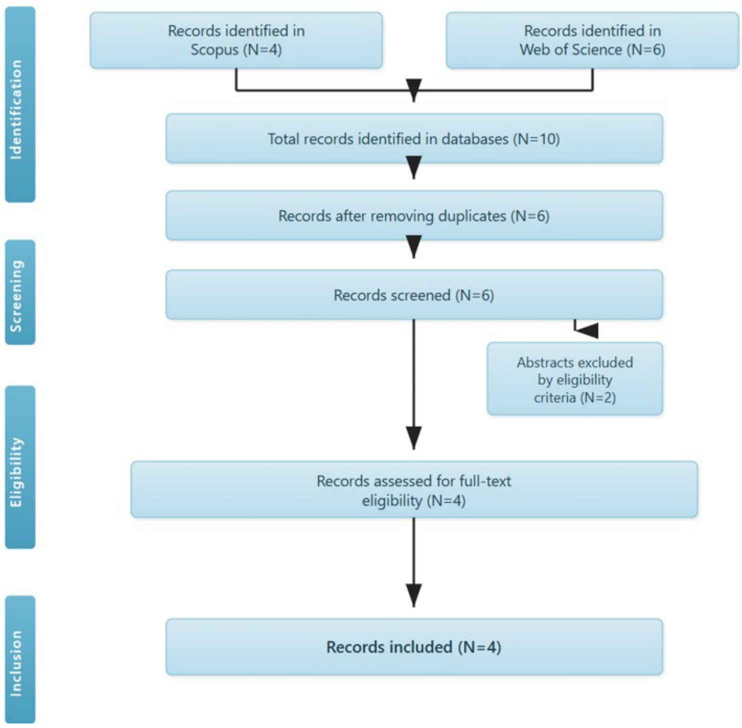

Figure 1. Search and selection process of publications.

The analytical process was structured in stages of initial coding, fragment review, and definitive assignment to the TPACK framework domains. To optimize document management and strengthen procedural transparency, the NotebookLM tool (Google) was employed. Specifically, NotebookLM was used to: (a) organize and index textual extracts from the four included publications, (b) generate preliminary summaries of key passages to facilitate cross-study comparison, and (c) identify potential thematic patterns across documents. It is important to note that all outputs generated by NotebookLM were subsequently reviewed, verified, and refined by the researcher, who retained full analytical control over the coding decisions, theme development, and final classification of findings. The use of this technology is supported by recent evidence highlighting how AI tools improve clarity and precision in qualitative data organization, while always maintaining human analytical control over the final classification (26-27).

3. Results

3.1 Teaching Competencies for the Use of Vibe-coding in Teaching from the TPACK Model.

3.1.1 Technological Knowledge (TK).

In the context of vibe-coding, TK is redefined: it no longer requires mastery of traditional programming languages. Instead, this competency lies in the interaction with Large Language Models (LLMs) through natural language and the management of the configurations of the platforms that host them. Its key elements are:

- *Structured Instructions.* Ability to write conversational yet rigorous prompts, clearly defining the learning objectives and desired characteristics of the application (28).
- *Iteration.* Recognition that the result is rarely perfect on the first attempt, which demands a continuous process of patience, refinement, and dialogue with the AI (28).

3.1.2 Technological-Pedagogical Knowledge (TPK).

- This domain manifests in the ability to structure technological development according to didactic goals:
- *Minimum Viable Product (MVP) Definition.* A Minimum Viable Product (MVP) refers to the simplest functional version of a tool that addresses the core educational objective. In the context of vibe-coding, this competency involves the ability to conceptualize and prioritize the essential features of a digital tool, avoiding unnecessary technical complexities and focusing development efforts on the most impactful pedagogical elements (20).
- *Task Breakdown.* Skill in dividing a complex pedagogical vision into small, clear instructions for the AI (e.g., "create an interactive questionnaire"), rather than requesting a complete application ambiguously (20).
- *Mapping of Objectives and Functionalities.* Constant evaluation to ensure that each interactive element of the application is anchored to a learning purpose, preventing functions from acting as mere technical distractions (20).

3.1.3. Pedagogical Knowledge (PK).

- With the elimination of the programming barrier, the success of the tool rests entirely on the educator's ability to inject their educational expertise into the system (20, 29):
- *Focus on the Learning Problem.* Cognitive transition from "can I build this?" to "how can I teach this better?", prioritizing the resolution of specific instructional difficulties over technical barriers (28).
- *Personalization.* Adaptation of content and interactivity considering the student's profile, age, competence level, and cognitive maturity (30).
- *Alignment of Learning Objectives.* Linking each function of the application (a button, a graph, an alert) to a specific educational objective, avoiding unnecessary features that distract the student (20).
- *Application of Theoretical and Cognitive Frameworks.* Knowledge of learning theories is required to structure the tool. For example, using schema theory to guide diagnostic reasoning or designing tasks that activate logical, analytical, and procedural thinking (28). Effective vibe coding uses educational theories to structure simulation design. For example, Schema Theory is used to guide students in the systematic construction of complex reasoning, such as differential diagnosis (28).

Table 1. Scientific publications on vibe coding for educators.

Publication	Country	Methodological Design	Study Population	Key Findings
Chow & Ng (2025). From technology adopters to creators: Leveraging AI-assisted vibe coding to transform clinical teaching and learning. *Medical Teacher*, 1-3.	Singapore	Descriptive research	Language instructors (with a focus on medical education)	Development of two applications in two hours by an educator with no technical background. Vibe coding facilitates the transition from technology adopters to creators, prioritizing pedagogical goals over programming barriers.
Shin, D., Lee, J. H., Lee, E., & Lee, Y. (2025). No-code approaches to developing ELT resources with generative artificial intelligence. *Elt Journal*, ccaf050.	South Korea	Descriptive research / Theoretical review	Language instructors (English teachers)	Vibe coding enables the creation of customized applications, such as the 'AI Career Pathfinder', using natural language. This eliminates reliance on IT professionals and fosters adaptive instruction.
Pesce & Cheungpasitporn (2025). Vibe Coding in nephrology education: clinician-led, AI-assisted development of open-source interactive learning tools. *Renal Failure*, 47(1), 2581933.	Italy and the United States	Proof-of-concept development study	Residents (nephrology trainees)	Rapid development of four interactive tools (e.g., Kidney Stone Navigator). The framework captures expert clinical reasoning and democratizes development for physician-developers.
Ng & Chow (2025). Empowering Health Professions Educators: Developing Educational Tools with AI-Assisted Vibe Coding. *Medical Science Educator*, 1-6.	Singapore	Descriptive academic monograph presenting practical strategies, step-by-step guidelines, and implementation examples (case study)	Health professions educators (specifically physicians and clinical teachers) seeking to develop customized digital applications without prior programming experience.	Vibe coding is identified as a means to democratize the creation of simulations by allowing non-technical educators to generate aligned pedagogical tools (such as the Differential Diagnosis Trainer) via natural language. The approach enables a shift in focus from technical feasibility to solving specific learning challenges.

- *Scaffolding of Cognitive Domains.* Cognitive scaffolding refers to the structured support provided to learners to help them progressively develop complex skills, which is gradually removed as competence increases. In the context of vibe-coding, the design of educational tools must incorporate scaffolding that activates different types of thinking: logical (define the problem), analytical (develop an approach), computational (identify patterns), and procedural (determine the steps of the solution) (20).
- *Evidence-Based Evaluation.* Pedagogical knowledge also manifests in the refinement phase. The ability to collect and analyze student feedback to adjust difficulty levels and clarify instructions is required (20, 30).

3.1.4 Pedagogical Content Knowledge (PCK).

It focuses on defining how specific disciplinary content should be taught by leveraging AI mediation:

- *Gap Identification.* Deep understanding of the audience to detect exactly where traditional methods fail (e.g., students who master theory but freeze under time pressure), designing a tool that addresses that deficiency (20).
- *Acquisition Principles.* Mastery of the fundamentals of how specific disciplinary skills are acquired to ensure that the tool is pedagogically sound (30).
- *Error Detection.* Testing the tool and detecting whether the AI has misinterpreted a medical algorithm or whether the results of a calculator are clinically dangerous (29).
- *Integration According to Cognitive Dimensions.* Involving different types of thinking: logical (define the problem), analytical (develop the approach), computational (identify patterns), and procedural (determine solution steps) (20).
- *Ethics and Safety.* Ability to establish "safety barriers" and write clear disclaimers, ensuring that students understand they are interacting with a simulation and not a real medical device (20, 29).
- *Authority Validation.* Since AI can generate errors or "hallucinations," the educator must possess sufficient content knowledge to act as the final auditor, ensuring that the tool is clinically accurate and safe before deployment (20, 29).

3.1.5 Content Knowledge (CK).

It is the most critical asset in medical education. As artificial intelligence handles technical syntax, the educator acts as a "clinician-developer" who provides disciplinary depth (29):

- *Deconstruction of Clinical Logic.* Ability to break down expert reasoning and the underlying pathological mechanisms into explicit logical steps.
- *Algorithm Mapping.* Transformation of static clinical practice guidelines into sequential decision trees (e.g., the relationship between serum potassium and anion gap in renal tubular acidosis) (29).
- *Dynamic Systems Modeling.* Understanding of physiological mechanisms to define the exact variables that the AI must calculate (e.g., insulin metabolism, effluent rate) (28-29).
- *Heuristics.* Knowledge of experience-based decision strategies (heuristics), which are often overlooked in rigid formal logic but are essential for independent clinical judgment (28).
- *Scenario Design.* Identifying specific problems, such as the difficulty students face in organizing diagnostic thinking under pressure, to design tools that specifically support that cognitive development (20, 28).

3.1.6 Technological Content Knowledge (TCK).

It refers to the understanding of how AI translates expert reasoning and clinical logic into functional digital tools. Technology acts as an active mediator through:

- *Technological Translation of Logic.* Deconstruction of mental processes into discrete steps that AI can process and faithfully represent (29).
- *Clinical Computational Thinking.* Identification of underlying patterns to generate simulations that are not only visually attractive but rigorously respect deterministic physiology (20, 28).
- *Mediation through Natural Language (Prompts).* Replacement of complex programming languages (such as Python or JavaScript) with structured natural language instructions that act as an interface to define the technical behavior of the application (28, 30).
- *Representation Auditing (Clinical Validation).* Rapid real-time iteration where the educator assumes final supervision. It is imperative to detect "hallucinations" or biased AI logic to ensure that the generated code is clinically accurate and safe before deployment (20, 29).

4. Discussion

The findings of this review suggest that vibe-coding is a paradigm shift that reconfigures the dimensions of the TPACK model in the use of Artificial Intelligence for Medical Education. Unlike traditional technology integration, where the educator adapts existing resources, vibe-coding enables a fundamental transition from "adopters" to "creators" of technology. At the same time, the quality of these created resources depends on the pedagogical and content knowledge that educators already possess.

The analysis reveals that Technological Knowledge (TK) in the era of Generative AI is grounded in the ability to structure conversational "prompts" and sustain an iterative dialogue with the system. In this context, TCK acts as an active mediator that translates expert clinical logic into functional algorithms through natural language. This emerging democratization empowers medical educators to materialize their pedagogical ideas autonomously, assuming a direct role as creators of technological tools. Notably, this reconfiguration of TK aligns with recent extensions of the TPACK framework, such as the Intelligent-TPACK (13-14) and GenAI-TPACK (11) models, which emphasize the need for AI-specific technological competencies that go beyond traditional digital literacy. The findings of this review suggest that vibe-coding may constitute a concrete manifestation of these expanded technological competencies, as it requires educators to develop proficiency in human-AI interaction rather than conventional programming skills.

A notable contribution of this study is the identification of the "clinician-developer" profile. The success of vibe-coding depends less on the tool and more on the educator's ability to deconstruct complex cognitive processes into sequential logical steps that AI can process. This is consistent with broader findings in the literature on AI integration in education, which indicate that AI does not replace pedagogical expertise; rather, it demands greater clarity in learning objectives and a more rigorous structuring of cognitive scaffolds to design effective MVPs (1, 7). Furthermore, the transition from technology adopter to creator has implications beyond clinical disciplines. While this review focused on medical education, the competencies identified are potentially transferable to other fields, including basic sciences, public health education, and health professions education more broadly.

A crucial finding is the auditing function that the TPACK model must assume in this context. Given the risk of AI hallucinations or errors in generated medical logic, Content Knowledge (CK) becomes the indispensable safety mechanism. The analyzed literature emphasizes that only an expert with deep disciplinary mastery can validate whether a simulation respects deterministic physiology or whether a clinical calculator is safe for use. This concern is particularly salient in medical education, where inaccurate algorithms or erroneous clinical logic embedded in educational tools could potentially propagate misconceptions among learners and, in extreme cases, compromise patient safety. Therefore, competency in vibe-coding intrinsically includes an ethical and validation dimension, where the educator is the ultimate guarantor of clinical accuracy. This aligns with the ethical decision-making component emphasized by the Intelligent-TPACK model (14), which positions ethical reasoning as a cross-cutting dimension of AI-enhanced teaching.

Limitations

This study presents several limitations that should be acknowledged. First, the corpus of analyzed studies is notably small (N=4), reflecting the nascent state of vibe-coding as a documented practice in education. This reduced sample limits the capacity to identify robust or generalizable patterns and restricts the scope of the conclusions that can be drawn. Second, the included studies encompassed both medical education and language teaching contexts; while the analysis prioritized findings relevant to medical education, the inclusion of a non-medical study (30) may affect the thematic coherence of the corpus, though it also provides a broader perspective on transferable competencies. Finally, all included publications date from 2025, reflecting the recent emergence of this phenomenon; consequently, the findings should be interpreted as preliminary and exploratory rather than as consolidated evidence.

5. Conclusions

- Vibe-coding may represent a significant competency with the potential to reshape educational practice in the era of Artificial Intelligence. Beyond a technical skill, this approach democratizes software development, enabling a fundamental transition in the teaching profile: from being mere technology adopters to becoming autonomous creators of educational resources. This emerging autonomy empowers educators to design complex simulators and interactive environments where students can manipulate variables and visualize cause-and-effect relationships, overcoming the limitations of traditional static resources.
- This analysis reaffirms the continued relevance and evolution of the TPACK model in AI-mediated educational contexts. The findings suggest that, while the technical entry barrier decreases thanks to natural language, the demands on Content Knowledge (CK) and Pedagogical Knowledge (PK) increase significantly. The educator assumes an indispensable role of ethical and disciplinary validation to ensure the accuracy of generated algorithms. Therefore, the successful integration of AI depends on the faculty's ability to orchestrate this knowledge in a robust instructional design.
- Finally, an urgent research agenda emerges from these findings. It is necessary to move beyond current descriptive studies to develop empirical research that evaluates the real impact of vibe-coding on the student learning experience and on teacher professional workload. Likewise, future studies should explore the effectiveness of vibe-coding across diverse medical education contexts. It is also recommended to define institutional training frameworks that not only teach prompt engineering but also foster the development of this new pedagogical-technological criterion, while establishing quality assurance mechanisms for AI-generated educational tools.

Funding: This study did not require funding.

Declaration of conflict of interest: The author declares no conflict of interest.

Data availability statement: This study is a scoping review based exclusively on published, publicly available scientific literature. No primary data were collected. The complete list of included studies is described in the Appendix section. Supplementary materials related to the coding process are available from the corresponding author upon reasonable request.

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