Revista Española
de Educación Médica

Innovative Educational Design in Oral Pathology: Current State of Evidence on Microlearning and Proposal of an Instructional Model.

Innovative Educational Design for Oral Pathology: Current evidence on microlearning and a proposed instructional framework.

Silvia Norma Carno, Ana del Carmen Aybar Odstrcil

[1] Laboratory of Pathological Anatomy. Faculty of Dentistry. National University of Tucumán. San Miguel de Tucumán. 4000. Argentina.
*Correspondence: anaybarster@gmail.com

Received: 10/2/26; Accepted: 31/3/26; Published: 1/4/26

Summary

Microlearning (ML) *has* become established as an innovative pedagogical strategy based on the presentation of brief, focused, and self-contained content, aimed at optimizing skills acquisition and reducing cognitive load. In the health sciences, its implementation has been enhanced by the use of digital tools (DGT), especially in virtual, hybrid, and mobile learning contexts. The objectives of this study were to analyze the available evidence on the use of ML and DGT in teaching oral pathology. A structured descriptive literature review was conducted, and based on the data obtained, an innovative instructional design for ML applied to the topic of malignant salivary gland neoplasms was proposed. A structured literature review was performed using PubMed, Google Scholar, and SciELO, with support from the SciSpace tool. Studies published between 2010 and 2025 that evaluated educational experiences based on virtual microscopy (VM) and/or digital visualization (DV) in the teaching of anatomical pathology or oral pathology were included. The results show that VM, especially through microvideos, flashcards, infographics, and gamification strategies, is associated with significant improvements in participation, satisfaction, and academic performance, surpassing traditional methods in several cases. In oral pathology, virtual microscopy (VM) stands out as a widely validated tool, promoting the understanding of histopathological patterns, clinicopathological integration, and diagnostic confidence. The integration of VM with DV, particularly with VM, represents an effective pedagogical approach for teaching oral pathology. Given that VM has been scarcely explored specifically in this area, the proposed instructional model gains relevance as an opportunity for educational innovation and highlights the need for longitudinal studies that evaluate its long-term impact and facilitate its curricular integration.

Keywords: Microlearning; digital tools; virtual microscopy; pathological anatomy; oral pathology; health sciences education.

Abstract

Microlearning(ML) has become established as an innovative pedagogical strategy based on the presentation of brief, focused, and self-contained content, aimed at optimizing skills acquisition and reducing cognitive load. In the health sciences, its implementation has been enhanced by the use of digital tools (DGTs), especially in virtual, hybrid, and mobile learning contexts. The objectives of this study were to analyze the available evidence on the use of ML and DGTs in teaching oral

pathology. A structured descriptive literature review was conducted, and based on the data obtained, an innovative instructional design for microlearning applied to the topic of malignant salivary gland neoplasms was proposed. A structured narrative literature review was conducted through searches in PubMed, Google Scholar, and SciELO, supported by the SciSpace tool. Studies published between 2010 and 2025 that evaluated educational interventions based on ML and/or DT in pathology or oral pathology were included. The results indicate that ML, implemented through microvideos, flashcards, infographics, and gamification strategies, is associated with improvements in student engagement, satisfaction, and academic performance, in several cases outperforming traditional teaching methods. In oral pathology, virtual microscopy (VM) stands out as a validated tool that enhances the understanding of histopathological patterns, clinicopathological integration, and diagnostic confidence. In conclusion, the integration of ML with DT, particularly VM, represents an effective pedagogical approach for teaching oral pathology. The proposed instructional design offers a relevant opportunity for educational innovation and highlights the need for longitudinal studies to assess its long-term impact and support its curricular integration.

Keywords: Microlearning; oral pathology; virtual microscopy; pathological anatomy; dental education.

---

1. Introduction

Microlearning (ML) is defined as an educational strategy based on delivering content in short, self-contained, and focused units, geared toward specific learning objectives (1-2). This asynchronous approach seeks to optimize the acquisition of skills through meaningful micro-content that reduces cognitive load and facilitates the understanding of complex concepts (3). Its development has been driven by the expansion of mobile devices and ubiquitous learning environments, allowing flexible access to knowledge in educational contexts where students' time is fragmented (1-4). Beyond simply fragmenting content, ML requires intentional instructional designs that integrate powerful, contextualized micro-content (MC) aligned with specific competencies (1-2).

From an applied perspective, MA is conceived as a strategy aimed at improving performance and the progressive acquisition of skills, promoting the immediate application of knowledge in real-world learning situations (5). Its implementation has been strengthened by Web 2.0 technologies and virtual learning environments, which favor hybrid and interactive educational experiences (1). However, several authors point out that effective MA should incorporate phases of anticipation, execution, and reflection in order to stimulate clinical reasoning and the progressive construction of knowledge networks, especially in disciplines of high cognitive complexity (6).

In the health sciences, multiple studies have shown that learning management (LM) supported by digital tools (DM) and gamification strategies improves student participation, satisfaction, and academic performance, in some cases surpassing the results obtained through traditional methodologies (3-7). Likewise, a decrease in cognitive load and greater motivation for self-directed learning have been described, key aspects for contemporary clinical training (7). It has also been observed that integrating LM with information and communication technologies, interaction through short videos, and gamified self-assessments promotes self-directed learning in medical students, particularly in conceptually dense areas such as physiology (8). In parallel, within anatomical pathology and oral pathology, the incorporation of DM such as virtual microscopy (VM) has shown promising results in terms of student acceptance, knowledge transfer, and strengthening of clinical reasoning (9-10-11-12). Recent studies also highlight the potential of virtual medicine (VM) combined with advanced digital resources and diagnostic algorithms to improve the acquisition of morphological skills (13). However, while evidence supports the advantages of

virtual medicine (VM) and digital learning (DL) in health education, debates persist regarding their impact on long-term retention, the development of higher-order cognitive skills, and the need for an appropriate balance between digital and face-to-face practical experience (14-15). Furthermore, most studies have focused on general medical disciplines, with limited structured application of VM, specifically in teaching histopathology in oral pathology.

In this context, this study aims to analyze the current evidence on the use of imaging techniques (IT) in health sciences education and oral pathology through a structured narrative review. Based on this framework, the study presents an instructional design using IT for teaching the histopathology of two of the most common salivary gland malignancies. The proposal is based on the integration of high-resolution visual imaging techniques (VITs) through guided active learning, with the goal of enhancing histopathological recognition, diagnostic reasoning, and the transfer of knowledge to future clinical practice.

2. Methods

This study was conducted as a structured descriptive literature review to analyze the available evidence on the use of microscopic imaging (MI) and digital imaging (DI) in the teaching of pathology, with a special focus on oral pathology. The literature search was performed in the PubMed, Scopus, Web of Science, SciELO, Google Scholar, and Semantic Scholar databases. The SciSpace tool was used to assist in the initial identification of relevant articles. The search was conducted between June 2025 and February 2026.

Combinations of English terms were used with Boolean operators: (“microlearning” OR “microlearning in medical education”) AND (“pathology” OR “oral pathology” OR “histopathology”) AND (“virtual microscopy” OR “digital tools” OR “e-learning”). The search included studies published between 2010 and 2025. Classic references were also included due to their conceptual relevance in defining microlearning and in the initial development of digital pedagogical models. Studies were included if they met the following criteria: original articles available in full text, published in the field of higher education in health sciences, and evaluating the use of microlearning and/or digital tools in oral pathology. Articles unrelated to higher education or lacking full-text availability were excluded.

3. Results

Available evidence suggests that learning management (LM) has a positive impact, superior to that of traditional teaching. Several studies have demonstrated the effectiveness of LM in different educational contexts. This strategy has been shown to optimize both the acquisition of theoretical knowledge and the development of practical skills in nursing students (3). It has been consistently noted that LM facilitates the transition from passive learning to an active, performance-based experience (16). Regarding implementation formats, micro-videos (<10 minutes) have emerged as one of the most effective tools. The brevity of the content has been described as facilitating complete viewing of the modules (8). Furthermore, high levels of participation (95%) and perceived usefulness (87.1%) have been reported through the use of short learning modules on social media (17).

Tabla 1. Resumen de principales hallazgos en estudios de microaprendizaje en ciencias de la salud.

Autor (Año)	Disciplina	Estrategia Evaluada	Resultados Destacados
Popovich & Katz (2009)	Farmacia	Presentaciones orales (7 min) y co-evaluación.	Entre el 78-91% reporta mejora en pensamiento crítico y feedback constructivo.
Manning et al. (2021)	Medicina	Bite-Sized Teaching (BST) entre pares (8 min).	Post-test superior (62.5% vs 55.2%). Alta aplicabilidad clínica (74%).
Ortega Hernández (2022)	Veterinaria	Píldoras de video (2-5 min) en Instagram.	87.1% refiere facilidad de estudio; mejora la atención en clase presencial.
González & Olaya (2023)	Fisiología	Microvideos (<10 min) y gamificación.	Fomento de la autonomía y mayor tasa de visualización de contenidos.
Sedaghatkar (2023)	Medicina	Micro-videos vinculados a TBL.	Optimiza la ejecución de tareas clínicas; ideal como complemento, no sustituto.
Albooghobeish (2025)	Enfermería	Microlearning vs. Tradicional.	Superioridad significativa en retención de conocimientos a largo plazo.

In the field of medical education, mental modeling (MM) has proven to be a relevant tool for transferring knowledge to clinical practice. In medical education, it was observed that 74% of residents applied what they learned in their clinical practice after MM sessions (18). Similarly, it has also been reported that integrating mental modeling into task-based learning (TBL) models improves the execution of medical procedures in real-world settings (19). Regarding the teaching of anatomical pathology and oral pathology, evidence highlights the central role of digital models, particularly visual models. In line with this approach, it was shown that integrating visual models into blended learning environments significantly improves theoretical understanding and diagnostic confidence (10). Consistently, these tools have been observed to promote diagnostic reasoning and clinicopathological integration (20), while greater efficiency in identifying histological structures in digital environments has also been reported (21). Regarding academic outcomes, most studies report improvements in performance, as well as high student acceptance. However, it has been noted that the optical microscope can still offer better results in certain contexts (22). Despite this, student preference leans towards virtual microscopy (VM) and other digital tools due to their accessibility, image clarity, and time efficiency. Overall, the analyzed studies position VM and the optical microscope as complementary strategies that promote the development of critical thinking, autonomy, and diagnostic accuracy in morphological disciplines (table 2).

Based on the reviewed evidence, a pedagogical integration scheme is proposed (Figure 1) that links the MA (presumably referring to a specific program or system) with the teaching of oral pathology. This model includes the selection of key content, its transformation into highly retainable micro-content, and its integration with digital tools, particularly the MV (presumably referring to a specific program or system). The process culminates in an evaluation focused not only on academic performance but also on the transfer of knowledge to clinical practice. The process begins with the identification of key content (histopathological patterns), which are transformed into highly retainable micro-content, such as micro-videos of less than 10 minutes and didactic cards (8). The integration phase with HD (presumably referring to a specific program or system)

relies heavily on the MV, which facilitates the transition to active pedagogical strategies such as task-based learning (TBL). This cycle culminates in an educational evaluation that measures not only academic performance but also the transfer to clinical practice and the student's diagnostic confidence (20).

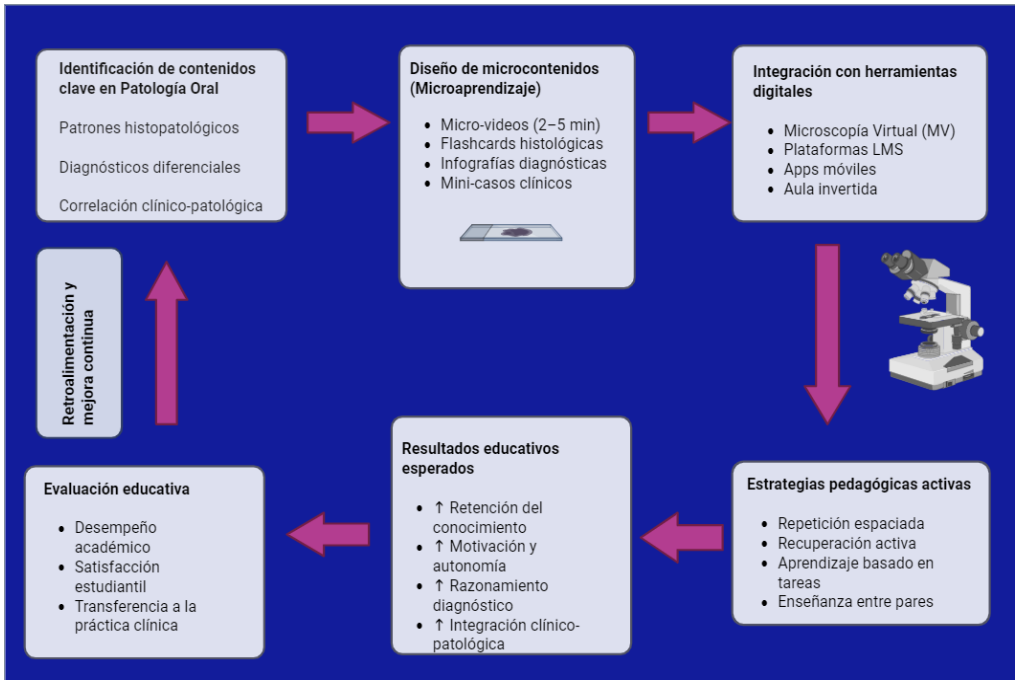

Figura 1. Esquema de la integración del microaprendizaje en la enseñanza de patología mediante herramientas digitales.

Table 2 Summary of included studies: methodological characteristics, technological tools and main findings in the teaching of oral histopathology.

Author (Year)	Design and Population (n)	Intervention / Tool	Key Findings
Szymas (2011)	Longitudinal (n=365)	WebMicroscope (Basic and Oral Pathology)	Perceived superiority over the optical microscope (OM); better preparation for clinical practice.
Fonseca (2015)	Observational (n=80)	Virtual Microscopy (VM) vs. Conventional Microscopy	Increased autonomy, motivation, and clinical-histological integration.
Ariana (2016)	Quasi-experimental (n=194)	Blended Learning + MV	Significant improvement in learning and diagnostic accuracy compared to the traditional method.
Brierley (2017)	Mixed (Qualitative/Quant.) (n=64)	MV vs. Conventional	It optimizes diagnostic reasoning and the integration of concepts.
Fernandes (2018)	Descriptive-comparative (n=165)	MV vs. Conventional	High pedagogical effectiveness specifically in Oral Pathology.
Zhong (2021)	Quasi-experimental (n=192)	MV + Remote Learning	Improves theoretical performance; high acceptance in distance education contexts.
Qing (2022)	Experimental (n=156)	IVMLS Platform	Improved final grades; hybrid use with MO is recommended.

Zhong (2023)	Quasi-experimental (n=214)	Flipped Classroom + OBE + VSETCD	Promoting critical thinking, teamwork, and better theoretical scores.
Irshad (2024)	Cross-sectional (n=40)	MV vs. Conventional (Leeds slides)	Greater operational efficiency and better identification of morphological structures.
Syed (2024)	Transversal ($n=79$)	Digital Microscopy (DM) vs. Conventional	The MO maintained better scores, but the DM was preferred for clarity and efficiency.

The reviewed evidence highlights the potential of the MA and the HD in teaching pathology, as well as the need for pedagogical approaches that systematically structure their implementation. Based on these findings, an instructional framework is proposed below that integrates these elements into a didactic sequence aimed at developing diagnostic reasoning.

3.1 Methodological proposal based on microlearning in oral pathology as an educational innovation tool.

Based on the evidence previously analyzed, a methodological design based on MA is proposed as an educational innovation strategy for teaching the histopathology of malignant salivary gland neoplasms to undergraduate and postgraduate students of oral pathology. *postgraduate students of oral pathology),* using self-developed teaching materials available online. The specific topics selected were Mucoepidermoid Carcinoma and Adenoid Cystic Carcinoma, as they are the most frequent malignant neoplasms in major and minor salivary glands, respectively.

The learning objective focuses on the identification, interpretation, and correlation of essential histopathological criteria for the diagnosis of both entities, through an instructional sequence structured in three progressive phases supported by high-resolution visual resources. In the first phase, guided knowledge acquisition, the use of short explanatory videos is proposed. These videos incorporate the learning of cell types and their main characteristics, highlighting the architectural patterns characteristic of each neoplasm, using high-quality virtual microscopy. The descriptions focus on recognizing essential diagnostic criteria and are available online (see attached supplementary material). The second phase involves active learning through the independent exploration of MV cases. Students must navigate and explore the online histopathological slides to identify and locate the histopathological components. These slides are not pre-marked, promoting morphological reasoning and diagnostic decision-making. (See attached supplementary material). As a third phase of cognitive consolidation, the use of synthetic visual materials in the form of illustrated slides is proposed. These present representative images accompanied by explicit labeling of the diagnostic histopathological criteria, thus reinforcing the visual recognition of cell types and the characteristic patterns of each entity.

Furthermore, its dissemination through social network X as an Open Educational Resource (OER) is planned, facilitating its accessibility and reuse. The images will serve as key examples for quick diagnostic reference, also promoting long-term retention (Figures 2 and 3). All the material is original and high-resolution, ensuring adequate observation of microscopic details.

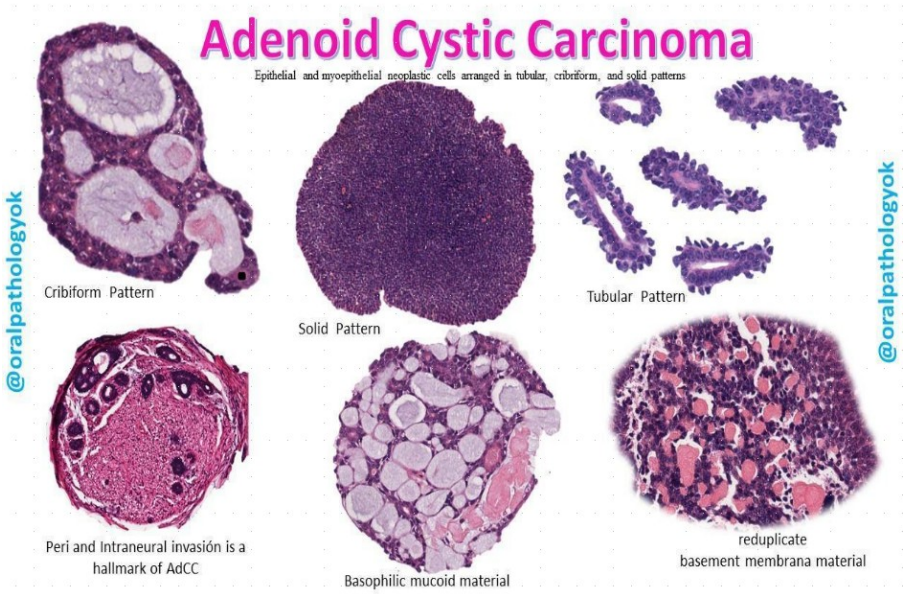

Figura 2. Publicación de @oralpathologyok en X, realizada en junio/2025. Slide con criterios diagnósticos microscópicos del Carcinoma Adenoide Quístico (CAQ).

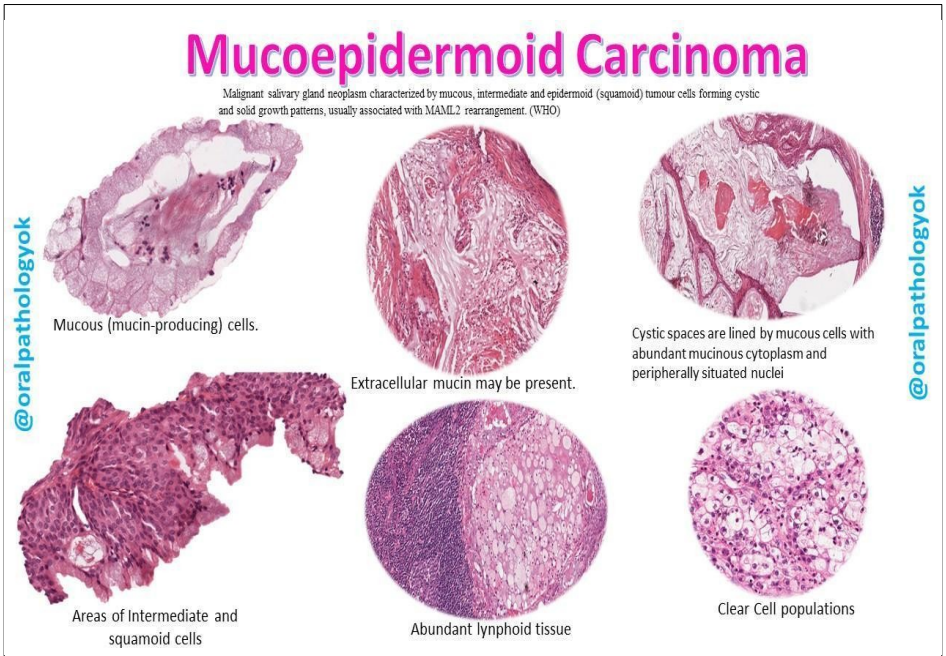

Figura 3. Publicación de @oralpathologyok en X, realizada en junio/2025. Slide con criterios diagnósticos microscópicos del Carcinoma Mucoepidermoide (CME).

For the future implementation of the proposed methodology, it is planned to add other entities from the WHO histopathological classification of salivary gland neoplasms, both benign and malignant. Furthermore, a mixed evaluation strategy is proposed, which will include a structured diagnostic rubric designed to assess morphological recognition, histopathological interpretation, and diagnostic formulation (Table 3), complemented by pre- and post-intervention objective tests

and student satisfaction surveys, according to an ad hoc designed model (Figure 4). The proposed diagnostic rubric is conceptually aligned with the approach of Professional Practice Assessments (PPAs), observable units of professional practice that can be used in student evaluation to assess the competencies achieved (28).

Tabla 3. Rúbrica propuesta de criterios de evaluación y niveles de formulación diagnóstica.

Criterio evaluado	Nivel alto (3)	Nivel medio (2)	Nivel bajo (1)
Identificación de patrones histológicos	Reconoce correctamente todos los patrones histopatológicos característicos.	Reconoce parcialmente los patrones histopatológicos	No reconoce los patrones histopatológicos
Identifica y localiza los tipos celulares	Ubica con precisión estructuras claves y tipos celulares.	Ubica algunas estructuras y algunos tipos celulares.	No logra identificar los tipos celulares.
Interpretación diagnóstica	Relaciona arquitectura y citología elaborando un diagnóstico certero.	Integración incompleta, no logra el diagnóstico de certeza.	Sin integración diagnóstica.

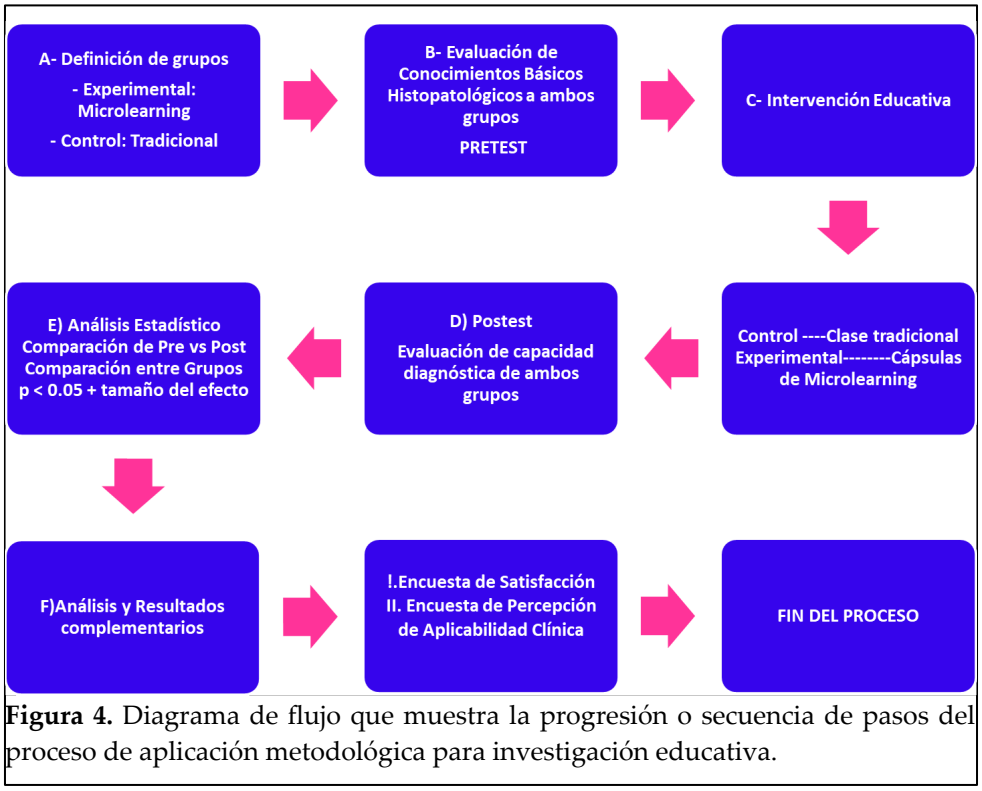

Figura 4. Diagrama de flujo que muestra la progresión o secuencia de pasos del proceso de aplicación metodológica para investigación educativa.

4. Discussion

The proposed model is based on the evidence analyzed in this review. In this sense, the guided acquisition phase It is based on studies that highlight the effectiveness of the MA for introducing complex content in short, focused units. The autonomous exploration phase is linked to the use of

HD, particularly MV, which allows for active learning and direct interaction with the content. Finally, the cognitive consolidation phase is based on active learning approaches and reinforcement strategies, which promote knowledge integration and the development of diagnostic reasoning. From the literature review, we observed that significant challenges remain for the consolidation of the MA (Multimedia Learning) approach as a standardized strategy. These include the heterogeneity of definitions, the diversity of implementation modalities, and the variability in evaluation indicators (2, 2, 3). We believe that the potential of the MA approach in teaching pathology can be realized by integrating clinical cases with virtual reality (VM) and digital platforms such as Moodle, using short modules that explain key histological structures, differential diagnoses, or clinicopathological correlations. Regarding accessibility, students could review the MA approach at any time, reinforcing what they have learned in the virtual laboratory or flipped classroom. Furthermore, it would allow for personalized adaptation of the pace and depth of learning to meet individual student needs.

Available evidence demonstrates that virtual learning (VL) and active methodologies (remote learning, flipped classroom, interactive platforms) have transformed the teaching of oral histopathology, improving academic performance and student satisfaction. However, one aspect that has been scarcely explored in this field is the use of short, focused, and anytime accessible modules to reinforce key content. Given that students value efficiency, image clarity, and the possibility of reviewing outside the classroom (14, 22-25), the use of modules appears as a natural extension of these digital strategies. Its integration could enhance knowledge retention, motivation, and autonomy by offering short modules on specific histological structures, differential diagnoses, or clinicopathological correlations (26).

Despite its proven effectiveness in other medical disciplines, media manipulation (MM) remains underexplored in the field of oral pathology. This presents a clear opportunity for future research evaluating its impact on the interpretation of histopathological images, diagnostic reasoning, and clinicopathological integration, especially when combined with tools such as microscopic visualization (MV) or the flipped classroom.

The review identified a gap in the field of oral pathology where microlearning has not been implemented. However, studies have shown that virtual microscopy (VM) enhances diagnostic accuracy. Specifically in oral pathology, Fernandes determined that the transition to digital methods is highly effective in improving specialized learning, overcoming the limitations of the conventional microscope. The included studies exhibit considerable heterogeneity in terms of methodological design, study population, educational interventions, and digital tools used. This variability hinders direct comparison of results and limits the possibility of drawing generalizable conclusions about the effectiveness of microlearning in oral pathology. The review's findings provide a basis for the proposed model's structure, in which each phase corresponds to educational strategies previously reported in the literature.

While the combination of machine learning (ML) and the use of high-quality digital (HD) technologies such as visual and active methodologies (e.g., flipped classroom or outcomes-based learning) has been previously explored in medical education, these approaches typically focus on integrating technological resources within general pedagogical frameworks, without specific structuring geared toward diagnostic training in morphological disciplines. In this sense, the distinctive contribution of this work lies in the proposal of an instructional framework specifically designed for oral pathology, which organizes learning in a progressive sequence of diagnostic challenges structured in three phases (guided acquisition, autonomous exploration, and cognitive consolidation). Unlike models such as blended learning or outcomes-based learning (OBE), which prioritize the teaching modality or competency assessment, the proposed model focuses on

optimizing morphological recognition and diagnostic decision-making through brief learning cycles, spaced repetition, and guided exposure to key histopathological patterns.

Among the limitations, it is acknowledged that the exclusion of studies not specific to oral histopathology could introduce conceptual bias, although this decision was based on the need to preserve the applicability of the proposed model to the disciplinary field. Furthermore, the transferability of the findings may be affected by contextual factors, such as the availability of technological resources, internet access, and Moodle UNT and virtual learning platforms, which is especially relevant in institutional contexts with infrastructure limitations. Regarding the proposed instructional model, it is important to note that its applicability and effectiveness have not yet been empirically validated. Consequently, future studies should evaluate its impact using experimental or quasi-experimental designs, considering variables such as academic performance, knowledge retention, and the development of diagnostic reasoning. Taken together, these limitations should be considered when interpreting the results of this study, and they highlight the need for future research to consolidate the evidence in this field.

5. Conclusions

- Literature analysis shows that the use of short, structured micro-content promotes knowledge retention, autonomous learning, and flexibility in training processes.
- The available evidence indicates that combining MA with resources such as virtual microscopy, diagnostic infographics, and gamification strategies improves the understanding of complex morphological patterns and strengthens clinical reasoning.
- Virtual reality (VM) is becoming established as a widely validated resource for optimizing flexible learning and diagnostic accuracy; however, the methodological heterogeneity of the studies and limitations in infrastructure and digital literacy restrict the generalizability of the results and the evaluation of long-term effects.
- The scarcity of specific research in oral pathology points to an emerging field of study, in which the proposed instructional model is presented as an innovative proposal consistent with the analyzed evidence and with potential for its integration into undergraduate and postgraduate training.

Ethical considerations. This study was reviewed and approved by the Ethics Committee of the Faculty of Dentistry at the National University of Tucumán, Report 01/2026. Since this is a literature review without direct intervention in human subjects or the use of sensitive data, informed consent was not required. For the future implementation of the proposed instructional model, informed consent will be obtained from participants in accordance with current bioethical regulations.

Funding: There was no funding for this work.

Declaration of conflict of interest: The authors declare that they have no conflict of interest.

Authors' contributions: SNC, study conception and design, methodological proposal design and ACAO, literature search and analysis, manuscript writing. Both authors, critical review of its intellectual content.

6. References.

1. Hug, T. Microlearning, A new pedagogical challenge (introductory note). In Hug, T., Lindner, M., & Bruck, PA (Eds.), Microlearning, Emerging concepts, practices and technologies after e-learning. 2006, pp. 8–11. Innsbruck University Press. htps,// api.semanticscholar.org/CorpusID,63961246
2. Yunianti, NPW, Khaerudin, K., & Kusumawardani, D. Microlearning as a digital learning strategy in higher health education, Literature review. *JPTK, Jurnal Pendidikan Teknologi dan Kejuruan.* **2025,** 22(1), 1–11. https://doi.org/10.23887/jptkundiksha.v22i1.90686
3. Albooghobeish, M., Ghalandeh, A., Khalafi, A., & Haghighizadeh, MH Using micro-learning to enhance knowledge and skills of airway management in nurse anesthesia

students, An interventional study. *Archives of Anesthesia and Critical Care.* **2024,** 11(1), 9–18. https://doi.org/10.18502/aacc.v11i1.17485

4. Hug, T. Mobile learning as "microlearning", Conceptual considerations towards enhancements of didactic thinking. *International Journal of Mobile and Blended Learning.* **2010,** 2(4), 47–57. https,//doi.org/10.4018/jmbl.2010100104
5. Torgerson C. The Microlearning Guide to Microlearning. Torgerson Consulting. 2016. ISBN, 0692806679, ISBN-13978-0692806678. https://teachonline.ca/tools-trends/searchable-directories/must-read-books-on-online-learning/microlearning-guide-microlearning/
6. Aldosemani, TI Microlearning for macro-outcomes, Students' perceptions of Telegram as a microlearning tool. *Lecture Notes in Educational Technology.* **2019,** pp. 189–201. https,//doi.org/10.1007/978-981-13-7361-9_13
7. De Gagne a, JC, Park, H.K., Hall, K., Woodward, A., Yamane, S., & Kim, S.S. Microlearning in health professions education, Scoping review. *JMIR Medical Education.* **2019,** 5(2), e13997. https://doi.org/10.2196/13997
8. González-Olaya, HL, Delgado-Rico, HD, Castillo-Toloza, WM, & Olarte-Marín, CD. Implementation and evaluation of a digital learning space for physiology using short instructional videos and gamification. *Educación Médica.* **2023,** 26, 121–127. https://doi.org/10.33588/fem.263.1282
9. Szymas, J., & Lundin, M. Five years of experience teaching pathology to dental students using the WebMicroscope. *Diagnostic Pathology.* **2011,** 6 (Suppl 1), S13. https,//doi.org/10.1186/1746-1596-6-S1-S13
10. Ariana, A., Amin, M., Pakneshan, S., Dolan-Evans, E., & Lam, AK Integration of traditional and e-learning methods to improve learning outcomes for dental students in histopathology. *Journal of Dental Education.* **2016,** 80(9), 1140–1148. https,//doi.org/10.1002/J.0022-0337.2016.80.9.TB06196.X
11. Fernandes, CIR, Bonan, RF, Bonan, PRF, Leonel, ACLS, Carvalho, EJA, de Castro, JFL, & Perez, DEC Dental students' perceptions and performance in use of conventional and virtual microscopy in oral pathology. *Journal of Dental Education.* **2018,** 82(8), 883–890. https://doi.org/10.21815/JDE.018.084
12. Odstrcil, ADCA, & Cariño, S. Use of virtual microscopy in the teaching and learning of oral pathological anatomy. *Spanish Journal of Medical Education.* **2024,** 5(4). https,//doi.org/10.6018/edumed.635251
13. Moura, JFBD, Eulálio, WES, Silva, MTB, & Bacchi, RR Integration of digital technologies to eliminate gaps in medical histopathology. *Sustainable Local Development.* **2024,** 17(62), e 2982. https://doi.org/10.55905/rdelosv17.n62-004
14. Zhong, Y., Zhang, Y., Sun, W., Li, L., Zhang, W., Jiang, Y., Lu, X., Cai, C., Wang, H., Liu, L., & Xu, Y. An outcomes-based module education via flipped classroom enhances undergraduate oral histopathology learning. *BMC Medical Education.* **2023,** 23. https,//doi.org/10.1186/s12909-023-04753-9
15. Sharmin, N., Kornerup, I., & Chow, A. Creating simple white board animations to explain complex tooth microanatomy. *Journal of Dental Education.* **2024.** https://doi.org/10.1002/jdd.13768
16. Popovich, N.G., & Katz, N.L. (2009). A microteaching exercise to develop performance-based abilities in pharmacy students. *American Journal of Pharmaceutical Education, 73* (4), Article 73. https://doi.org/10.5688/aj730473
17. Ortega Hernández, N. Microlearning as a teaching tool in the subject Microbiology I of the Veterinary degree. Anales *de Veterinaria de Murcia.* **2022.** DOI, 10.6018/analesvet.542361
18. Manning, KD, Spicer, JO, Golub, L., Akbashev, MY, & Klein, R. The microrevolution, Effect of bite-sized teaching on learner engagement and learning in postgraduate medical education. *BMC Medical Education.* **2021,** 21(1), 1–11. https,//doi.org/10.1186/S12909-021-02496-Z

19. Sedaghatkar, F., Mohammadi, A., Mojtahedzadeh, R., Gandomkar, R., Rabbani Anari, M., Dabiri, S., Tajdini, A., & Zoafa, S. Enhancing medical students' knowledge and performance in otolaryngology rotation through combining microlearning and task-based learning strategies. *International Journal of Environmental Research and Public Health.* **2023,** 20(5), 4489. https,//doi.org/10.3390/ijerph20054489
20. Brierley, DJ, Speight, PM, Hunter, KD, & Farthing, PM Using virtual microscopy to deliver an integrated oral pathology course for undergraduate dental students. *British Dental Journal.* **2017,** 223(2), 115–120. https,//doi.org/10.1038/sj.bdj.2017.626
21. Irshad, M., Khan, I., Sarfaraz, A., Tariq, SF, Shabir, H., & Rashid, S. Virtual microscopy as an effective tool for oral pathology teaching at undergraduate level. *Journal of the Pakistan Dental Association.* **2024,** 33(1), 7–9. https://doi.org/10.25301/jpda.331.7
22. Syed, SMGA, Zafar, SS, Syed, FA, Iqbal, A., & Atif, S. Comparison of light microscopy and digital microscopy for learning oral pathology practices among dental students. *Journal of Dental Sciences.* **2024.** https,//doi.org/10.1016/j.jds.2024.03.022
23. Zhong, Y., Sun, W., Zhou, L., Tang, M., Zhang, W., Xu, J., Jiang, Y., Liu, L., & Xu, Y. Application of remote online learning in oral histopathology teaching in China. *Oral Medicine, Oral Pathology and Oral Surgery.* **2021,** 26(4). https,//doi.org/10.4317/MEDORAL.24441
24. Qing, J., Cheng, G., Ni, X., Yang, Y., Zhang, W., & Li, ZP Implementation of an interactive virtual microscope laboratory system in teaching oral histopathology. *Scientific Reports.* **2022,** 12(1). https,//doi.org/10.1038/s41598-022-09473-6
25. Szymas, J., & Lundin, M. Five years of experience teaching pathology to dental students using the WebMicroscope. *Diagnostic Pathology,* **2011,** *6* (Suppl 1), S13. https,//doi.org/10.1186/1746-1596-6-S1-S13
26. Fonseca, FP, Santos-Silva, A., Lopes, MA, Almeida, OP, & Vargas, PA Transition from glass to digital slide microscopy in the teaching of oral pathology in a Brazilian dental school. *Oral Medicine, Oral Pathology and Oral Surgery.* **2014,** 20(1). https,//doi.org/10.4317/MEDORAL.19863
27. Liberati, A., Altman, D.G., Tetzlaff, J., et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions. *PLoS Medicine.* **2009,** 6(7). DOI, 10.1016/j.jclinepi.2009.06.006
28. Ten Cate, O., & Taylor, D.R. The recommended description of an entrustable professional activity, AMEE Guide No. 140. *Medical Teacher,* **2021,** 43(10), 1106–1114. https,//doi.org/10.1080/0142159X.2020.1838465