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Original article

Digitalization and Gamification to Improve Pathology Education: The SIAPeC Quiz Experience

Alessandro Caputo[1,2], Luca Cima[3], Vincenzo L'Imperio[4], Giuseppe Alecci[5], Andrea Ascione[6], Mattia Facchetti[7], Özgür Can Eren[8,9], Brett Baskovich[10], Kamran M. Mirza[11], Michael Bonert[12], Guido Fadda[13], Filippo Fraggetta[14]

[1]Department of Medicine, Surgery, and Dentistry "Scuola Medica Salernitana", University of Salerno, Baronissi, Italy; [2]Department of Pathology, University Hospital of Salerno, Salerno, Italy; [3]Department of Diagnostic and Public Health, Section of Pathology, University and Hospital Trust of Verona; [4]Department of Medicine and Surgery, Pathology Unit, Fondazione IRCCS San Gerardo dei Tintori, University of Milano-Bicocca, Monza, Italy; [5]Department of Health Promotion Sciences, Maternal and Infant Care, Internal Medicine and Medical Specialties (ProMISE), Pathology Unit, University of Palermo, Palermo, Italy; [6]Department of Experimental Medicine, Sapienza University of Rome, Rome, Italy; [7]Department of Pathology, ASST Spedali Civili di Brescia, Brescia, Italy; [8]Department of Pathology, Koç University School of Medicine, Istanbul, Turkey; [9]Koç University Research Center for Translational Medicine, Istanbul, Turkey; [10]Department of Pathology, Icahn School of Medicine at Mount Sinai Health Systems, New York, NY, USA; [11]Department of Pathology and Clinical Laboratories, Michigan Medicine, Ann Arbor, MI, USA; [12]Department of Pathology and Molecular Medicine, Division of Anatomical Pathology, McMaster University, Hamilton, Ontario, Canada; [13]Department of Human Pathology of adulthood and childhood "Gaetano Barresi", University of Messina, Messina, Italy; [14]Department of Pathology and Laboratory Medicine, ASP Catania, Catania, Italy

Summary

Pathology education is evolving beyond traditional textbooks and increasingly embracing digital and active learning tools. While passive methods of teaching such as lectures remain dominant, active learning approaches-such as case-based learning, gamification, and technology-enhanced education-are on the rise. Tools like digital microscopy, social media, and resources such as Libre Pathology and pathCast are democratizing access to knowledge, fostering interactivity and accessibility.

Quizzes and gaming events have become essential tools in medicine, enhancing learner engagement, honing diagnostic skills, and promoting collaborative learning. Notable examples in pathology include the ESP Pathology Progress Test, the RCPath International Pathology Day Quiz, and interactive events like the ISDP Dermatopathology Olympic Games. Gamification not only boosts motivation but also facilitates the practical application of real-world skills. These innovations are particularly impactful in pathology, where simulated diagnostic challenges offer realistic learning experiences.

The inaugural SIAPeC Quiz (2024) demonstrated the efficacy of gamification in pathology education, combining interactive case-based challenges with digital tools to enhance diagnostic skills and engagement among junior pathologists. Featuring a diverse range of questions across histology, pathology, and subspecialties, the event incorporated whole-slide images and challenges that push the boundaries of what can be understood from minimal information (#TooCloseToDiagnose and #TooFarToDiagnose). This gamified format created a supportive environment for learners to experiment and learn from mistakes, fostering critical skills in a dynamic setting.

Keywords: gamification, technology-enhanced learning, pathology education, medical training, educational innovation

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Correspondence
Alessandro Caputo
E-mail: alcaputo@unisa.it

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The 2024 SIAPeC Quiz experience

Design and Objectives

The inaugural SIAPeC Quiz, held during the 2024 annual meeting of the

Figure 1. Photographs taken during the 2024 SIAPeC Quiz. Participants are engaged with the quiz, using their smartphones to answer the questions, and can be seen discussing and thinking.

Italian Society of Pathology and Diagnostic Cytology (SIAPeC), was designed to evaluate the utility of gamification in pathology education. Targeting junior pathologists (residents and fellows under 35 years), the session aimed to: (1) assess diagnostic skills through interactive, case-based challenges simulating real-world scenarios; (2) promote active learning by incorporating immediate feedback; (3) foster participant engagement with digital tools, including whole-slide images (WSIs) and multimedia platforms (Fig. 1). The questions spanned a spectrum of complexity, from basic pattern recognition to diagnostically challenging scenarios incorporating common pitfalls. This approach allowed trainees to safely encounter and learn from errors in a simulated environment, reinforcing skills transferable to real-world diagnostic practice.

Implementation

The quiz was deployed using Quizizz (https://quizizz.com, retrieved on 2024-12-11), a web-based platform selected for its compatibility with multiple types of questions (text, static images, links to WSIs) and answers (multiple choice and open), and real-time pacing. Participants accessed the quiz via personal smartphones, eliminating the need for specialized hardware.

The quiz included a total of 27 questions. Twelve (44.4%) questions had multiple-choice answers, while 15 (55.5%) had open-text answers. Fifteen questions (55.5%) featured static images, 12 (44.4%) featured WSIs, and 7 (25.9%) featured interactive ancillary technique requests (some questions featured multiple of these modalities).

Questions varied widely in terms of knowledge domain required to answer, ranging from normal histology to general surgical pathology, diagnostic reasoning, clinical correlation, ancillary technique interpretation, and pathology subspecialties (dermatopathology, neuropathology, *etc.*).

For example, one question showed a small region of gastric oxyntic mucosa with glands oriented horizontally (Fig. 2). The image was cropped to only show the deep part of the glands, with a predominance of principal cells on the left and parietal cells on the right, and the question asked “Which way is the lumen?” (with multiple choice answer: left, right, up, down).

In some questions, recognition of the depicted entity was required but not sufficient alone to answer correctly; further knowledge was essential to answer. For example, one question showed an image depicting molluscum contagiosum and asked about its etiology, requiring first to recognize the entity, and then knowledge about its etiology (possible answers: congenital, viral, radiation, urticating agents). Another question showed a biopsy with collagenous colitis and asked about its associated endoscopic features (possible answers: pseudomembranes, erosions, diverticula, none). Another question showed a gastric neuroendocrine tumor and then two IHC slides with cytoplasmic positivity, and the question asked what antibodies were shown (with options including chromogranin+synaptophysin and chromogranin+INSM1, requiring not only morphologic recognition of the neuroendocrine tumor, but also knowledge about subcellular localization of the proteins to answer correctly). Another question showed a Russell body gastritis and asked about the nature of the eosinophilic substance (mucin, immunoglobulins, vesicles, mitochondria), mimicking a potential real-world pitfall.

Other questions were based on the Twitter hashtag #TooCloseToDiagnose (n=3, 11.1%), where partici-

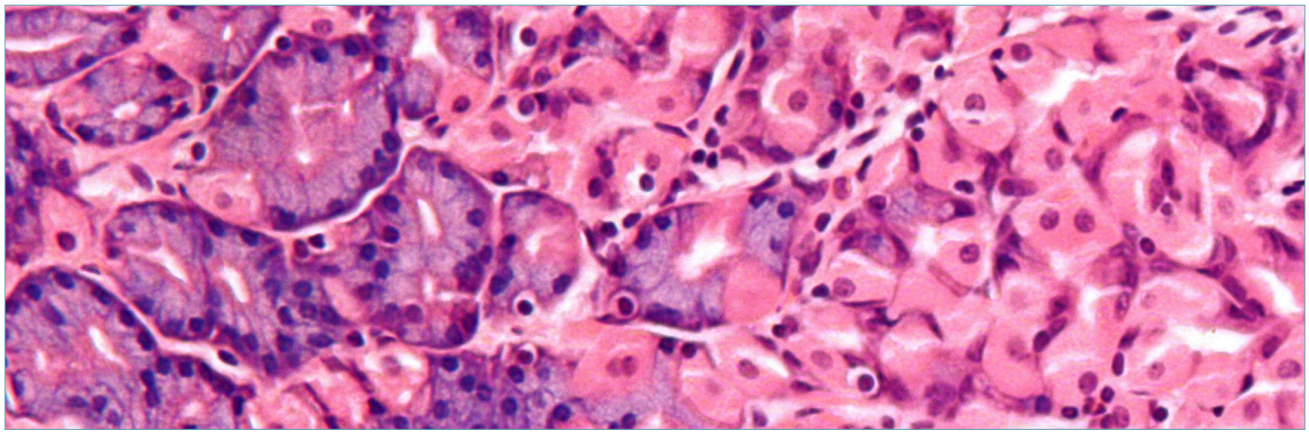

Figure 2. A cropped version of the picture "Normal gastric mucosa intermed mag" by Wikipedia user Nephron. The crop hides the easily recognizable parts of the glands (bases, necks, and surface) and requires knowledge about the relative orientation of principal and parietal cells to reorient. The original picture from which this version is derived was voted and elected as a featured picture on the English language Wikipedia and is considered one of its best images.

pants were shown a specific high-power static image of a defining diagnostic feature of an entity (in our case: malakoplakia, Leydig cell tumor). This excludes all other possible hints towards the diagnosis (clinical features, low-power view) and forces participants to recognize and interpret a specific microscopic feature. Here, participants were not offered multiple choices but had to type in their answer, to increase difficulty.

Similarly but in the opposite direction, some questions were based on the #TooFarToDiagnose hashtag (n=2, 7.41%), where the diagnosis has to be reached with only a low-power image. Examples here included a Warthin tumor and a pilomatrixoma. Here, too, participants had to type their answers.

Another set of questions (n=7, 25.9%) was based on the website drdoubleb.com [1]. These included most of the features discussed above: they were based on WSIs with clinical information; participants could request additional tests (immunohistochemistry, FISH, *etc*) and the results would then be shown as WSIs or images, requiring further interpretation. These cases resembled routine clinical practice the most, required all the skills introduced in the previous questions (pattern recognition, clinical correlation, diagnostic reasoning), and included examples of alveolar soft part sarcoma, NUT carcinoma, and follicular lymphoma.

Findings

Participant scores ranged from 4,910 to 20,560 points (median 12,225), with 5-21 correct answers (median 12.5), 1-17 incorrect answers (median 10.5), and 0-21 unanswered questions (median 2). The three highest-scoring participants achieved 20,560, 20,330, and 17,430 points, with 21, 21, and 18 correct answers, respectively, and no unanswered questions. Across all questions, the correct response rate ranged from 0% to 100% (median 41%), while the mean time to respond ranged from 5 to 215 seconds (median 69 seconds). Qualitatively, higher correct response rates were observed for questions depicting common entities with typical features, whereas lower rates were associated with rarer diagnoses, open-text responses, and intentionally information-limited formats such as #TooCloseToDiagnose and #TooFarToDiagnose. These patterns are consistent with the educational goals of the initiative, which emphasized diagnostic reasoning under variable and sometimes constrained conditions rather than formal assessment.

The session successfully achieved its dual objectives of educational value and participant engagement. Feedback indicated that the quiz effectively covered a broad range of difficulty levels, from foundational knowledge to complex diagnostic challenges. The interactive format was particularly well-received, with participants reporting enhanced diagnostic confidence through exposure to simulated pitfalls (personal communications). Notably, many participants identified at least one new pathology concept or entity learned during the session, demonstrating the quiz's efficacy as a supplementary educational tool.

Live demonstrations of featured websites, including usage tips, were provided during and after the quiz. A significant proportion of participants reported being previously unaware of at least one of these resources, highlighting a gap in digital resource literacy among trainees. Additionally, for some participants, the quiz

represented their first hands-on experience with WSIs for diagnostic purposes, which they identified as a valuable component of their learning.

We also encountered some problems that represent areas for improvement for the next editions of the quiz. Despite efforts to standardize responses (e.g., requesting acronyms like "SCAP" for Syringocystadenoma papilliferum or single-word answers like "Hodgkin"), spelling variations (*e.g.*, "spiroadenoma" *vs.* "spiradenoma") occasionally hindered answer recognition. A minority of participants experienced initial difficulties connecting to the quiz via smartphones, though these were resolved with minimal delay.

Quizzes in pathology and medicine

Similar experiences in pathology

Pathology congresses increasingly use interactive quizzes to engage participants, test diagnostic skills, and foster collaborative learning. These events employ slide-based challenges, multiple-choice questions (MCQs), and virtual diagnostics, targeting trainees and practicing pathologists (Tab. I).

For example, the European Society of Pathology (ESP) organizes every year the Pathology Progress Test (PPT). This test is primarily intended for pathology residents; it consists of 120 text-, image- and WSI-based MCQs covering various subspecialties such as histopathology, molecular pathology, and diagnostic techniques. The ESP PPT is purely formative as it serves as a self-assessment tool and the individual results are kept anonymous [2]. Similarly, the Royal College of Pathologists (RCPath) offers a global Undergraduate Quiz for medical students, emphasizing disease prevention and diagnosis.

Another example of gaming experience during pathology congresses occurred during the 2024 European Congress of Pathology (ECP) organized in Florence by the European Society of Pathology: a special uropathology session called "How to approach GU tumors: a gaming experience". During this session, the main tumors of the urogenital tract were explored through a gaming event performed on the digital platform Kahoot!, in order to identify the correct diagnostic approach for these neoplasms and highlight any potential diagnostic pitfalls [3].

A true competition was organized by the International Society of Dermatopathology (ISDP) in June 2024, the ISDP Dermatopathology Olympic Games: an online competition specifically intended for pathology and dermatology residents and trainees. During this event, challenging dermatopathology cases were presented and the participants answered questions revolving around microscopic diagnosis. The winners were granted prizes, such as 1-year free IDSP membership, 50% off registration for the ISDP Joint Meeting and 30 minutes online with a dermatopathologist.

Similar experiences in other medical specialties

Quizzes and gaming events held during scientific congresses are a common practice also in other medical specialties. Interactive quizzes are often administered to congress participants at the end of sessions, to engage the audience and to reinforce the concepts expressed during the presentations. These interactive games, held during medical congresses, revolve typically around clinical cases and focus on the correct diagnosis and management, serving as a tool to start a debate between the participants [4-6].

Italian and European congresses of radiologists, such as the ones organized by the European Society of Radiology and Società Italiana di Radiologia Medica e Interventistica, organize sessions focused on quiz competitions specifically intended for residents [7]. This

Table I. Examples of Gamified Learning Models in Medical Congresses

Discipline	Event Name	Organizer	Format / Content
Pathology	Pathology Progress Test (PPT)	European Society of Pathology (ESP)	120 MCQs (text, image, WSI); subspecialty coverage
Pathology	International Pathology Day Undergraduate Quiz	Royal College of Pathologists (RCPath)	Broad pathology topics, disease prevention, diagnosis, treatment
Pathology	"How to approach GU tumors: a gaming experience"	European Society of Pathology (ECP 2024)	Gaming session on GU tumors, diagnostic challenges
Dermatopathology	ISDP Dermatopathology Olympic Games	International Society of Dermatopathology (ISDP)	Competitive quiz on microscopic diagnosis
Radiology	Quiz Competitions	European Society of Radiology; SIRM	Imaging-based diagnostic quizzes
Cardiology	SIC Cardiopentathlon	Società Italiana di Cardiologia (SIC)	MCQs on clinical guidelines and management; virtual + in-person final

type of competition challenges participants to analyze imaging scans and identify the correct radiological diagnosis.
A peculiar kind of gaming event is held annually during the national congress organized by Società Italiana di Cardiologia (SIC): the SIC CARDIOPENTATHLON, a quiz session intended to test residents' knowledge of clinical guidelines and case management. Specifically, 40 groups of residents are selected inside each school and have to answer MCQs during virtual events, using the gaming platform Kahoot!. The highest-scoring six groups access the in-person event, typically held during the annual congress, and participate in a quiz session with a format recalling television quizzes [8].

Digital resources for pathology education: beyond books

Pedagogy and learning

Medical professionals, especially in the academic setting, have to face the challenge of being called to teach to medical students and to younger colleagues while usually having no specific pedagogy training themselves. Unfortunately, this "pedagogical analphabetism" can cause sub-optimal transmission of knowledge, resulting in further strain on the learning system. We believe that efforts should be made to reverse this trend, both by investing in the preparation of the teacher figure and by giving the students proper and modern means to optimize their learning.
Broadly, two learning approaches can be distinguished [9]. **Passive learning** is the traditional lecture-based, one-way information transfer with minimal feedback and interaction, often resulting in memorization through rehearsal [9]; **active learning**, in contrast, engages students through case-based discussions, simulations, and flipped classrooms, fostering an active role for the students and promoting critical thinking and long-term retention [9-11].
According to well-established evidence, active learning leads to more dynamic, engaged learning experiences that have been shown to foster better retention, enhanced critical thinking, and development of practical knowledge, especially in fields like medicine [12].
However, academic medical education is still often a matter of passive learning, where huge textbooks are the reservoirs of knowledge from which the student has to mine the relevant information and then rehearse it endlessly to internalize it, usually temporarily. This approach has been defined as "cramming", and is the result of a mentality where passing the exam is the final aim, but it is far from being optimal when we consider the skills a medical doctor will be required to possess in his/her future daily practice [13]. Active learning on the other hand can be pivotal in familiarizing with real-world scenarios, in developing problem-solving skills and in favoring long-term retention of the gained knowledge, as well as providing learners with confidence in their newly acquired skills [9,14,15].
Limitations to the diffusion of active learning methods in the field of medical education include the fact that, compared with passive learning methods, they tend to be more time consuming both for students and teachers. Indeed, the amount of information a medical student has to face is truly overwhelming, and teachers can feel like the only way to go through everything is to promote passive learning. Ultimately, while active learning requires a greater time investment, the long-term benefits in terms of learning outcomes and skill development often outweigh these costs, especially in professional fields like medicine. Balancing both methods and incorporating active learning strategies where appropriate can lead to an optimal educational experience [16].
This optimal scenario can also be enhanced by the application and fostering of memorization techniques that have proven helpful tools in the process of learning, such as spaced repetition and active recall. These methods exploit our knowledge of the way the human brain internalizes and forgets information in order to solidify the understanding and learning process, avoiding the problems and limitations associated with cramming and promoting long-term retention [17].

Gamification

The term gamification refers to the application of game-like rules and dynamics to a non-game context. Such dynamics include challenges of increasing difficulty, team building, rewards, points, and leaderboards [18].
Gamification has been studied in the context of medical and non-medical education and is known to have a plethora of possible benefits for the students. Indeed, it is known to increase the levels of engagement and motivation of the students, and therefore their ability to retain information. By creating an environment of friendly competition, gamification of the learning process can sharpen problem-solving and decision-making skills, while also boosting confidence, leadership, and cooperative qualities. Real-life scenarios where lives are at risk can be simulated in a safe-to-fail environment, protecting the students from stress, trauma, and burn-out [15,18,19]. A key concept in gamification is that of instant feedback. By instantly relaying to the player the result of actions,

gamification of learning can constantly and efficiently inform the student about their current level of knowledge and can prevent the retention of wrong information [20]. This perspective is radically different from the one where the student has to wait until the end of the semester to test their knowledge in the exam setting, running the risk of being unprepared for it without even being aware. Gamification can also compress learning; ancillary test results (immunostains, molecular tests) may be instantaneous in a game, instead of requiring days or weeks. A simulated environment can avoid forgetting important contextual information the learner needs to understand connections between ancillary tests and the preceding work-up. Gamification can also take the form of constraints imposed on the gamer in order to sharpen specific skills and limit reliance on usual strengths, a type of training that isn't truly feasible in real life.

Among other aims and advantages, gamification in the setting of education naturally has the one of making learning a fun activity. Learning and having fun are often perceived to be at odds with each other, but in reality they can be combined fruitfully. When students engage in gamified learning, they experience a more enjoyable and immersive process that encourages sustained attention and deeper involvement. This positive emotional engagement, in turn, can enhance memory retention and comprehension, making complex topics more approachable. Additionally, the integration of playful elements into education fosters a sense of curiosity and exploration, motivating students to take an active role in their learning rather than passively receiving information. By blending enjoyment with educational goals, gamification creates an environment where students can experiment, take risks, and make mistakes in a low-stakes setting-promoting a growth mindset. Ultimately, the fusion of fun and learning not only helps alleviate the pressures of traditional educational settings but also cultivates a more holistic and engaging approach to acquiring knowledge and developing critical skills.

Gamification in some sense is not new. One of the more senior authors remembers exam practice facilitated with "teaching recuts" (glass slides). It was certainly more cumbersome than what is done today via electronic means. It also depended on the formal support of the institution to make the recuts. Residents had permission to order teaching cuts and many residents had boxes of recuts at the end of their training-these facilitated the quizzing sessions. The graduating residents would take their recuts with them and invariably good teaching cases would be lost to the institutional pathology archives.

Similarly, gamification must not necessarily be limited to graduate medical education but might be integrated in the wider continuing medical education (CME) framework, where it could address several inherent challenges. In addition to increasing engagement, such methods might pave the way for more robust medical practices by creating a dynamic learning environment. For example, the American Board of Medical Specialties requires self-assessment modules for continuing board certification, which typically take the form of MCQs. While effective to an extent, these assessments lack the interactivity and nuanced feedback of gamified systems, suggesting that a more interactive, game-like framework could better support lifelong learning and ultimately improve patient outcomes [21].

Beyond books

Today's tech-savvy learners expect multimodal resources beyond textbooks. Technology-enhanced learning (TEL) includes virtual simulations, computerized mannequins, and online learning modules. A boost to the diffusion of TEL has come from the effects of the COVID-19 pandemic [12,22,23]. TEL is expected to impact medical education massively, as it is bound to improve several of its critical issues, including the personalization of the learning experience, known to be different across students [24].

Online modules and courses were found to improve the exam scores and knowledge retention of medical students, particularly when compared to traditional lecture-based methods. These tools can be particularly effective at sharpening specific practical skills which can be difficult to acquire in the academic settings, such as cardiac and pulmonary auscultation and virtual reality for surgical operations [25,26].

TEL was not very practical a generation ago, when pathology information sources were primarily offline and it was difficult to find high-quality pathology images online of common and uncommon entities. Early on-line quizzes in the pathology realm include "Blue Histology" (which was directed at medical students and taught basic histology) and Virtual Autopsy (which is what the name suggests). Both are no longer online but can be accessed through archive.org [27,28].

Training for young pathologists

Pathology training often defaults to passive learning despite being ideally suited for active approaches [29]. In fact, by having a final diagnosis as usual aim and pattern recognition as the main tool for histological diagnosis, the daily practice of pathology can very easily be simulated by quizzes and tests, making gamification an extremely appealing strategy for teachers in this field [30].

Furthermore, reaching a final histopathological diagnosis is often not only dependent on traditional histology alone, with several ancillary techniques and clinical information playing a fundamental role. In the context of a simulation, it is easy to limit access to some of these tools in order to sharpen the ability of working with what is left.

The digital revolution of pathology is bound to deeply improve pathology training [31-33]. WSIs are easy to share and can be effortlessly labeled to make retrieval of peculiar cases very simple for teaching and research purposesg [34-36].

Accordingly, several pathology-related websites and content creators have emergedg [37]. The individuals behind these channels often use game-derived mechanics to promote engagementg [38,39]. For instance, they may ask to formulate a diagnosis based only on a high-power (or low-power) field of a lesion. These two real-life examples have gained popularity on Twitter under the hashtags #TooCloseToDiagnose and #TooFarToDiagnose.

The undisputable success of these social media ventures in terms of followers and engagement is testimony to the appeal a "gamified pathology" can have for our community, and should be a source of inspiration for those that are tasked with the education of pathology trainees and with the enticement of medical students towards our beautiful discipline [39].

Practice

Modern pathology education blends traditional methods with innovative digital tools (Tab. II), such as virtual microscopy, online case-based learning, telepathology, and the use of social media for knowledge dissemination [40,41].

Social media is playing an important role in the larger trend toward free and open access medical educationg [42]: platforms like KiKo (Knowledge In Knowledge Out) and X (formerly Twitter) host vibrant pathology communities posting intriguing cases, images, and diagnostic challenges, together with diagnostic tips and lessons.

Dr. Brett Baskovich's website, drdoubleb.com [43] is a dynamic playground where participants can strengthen their skills through hands-on interaction. The website features a series of interactive cases that integrate clinical history with WSIs, providing participants with the opportunity to request additional tests like immunohistochemistry or FISH. Results from these tests are again presented through WSIs, requiring participants to further interpret the findings to arrive at a diagnosis.

The University of Leeds' virtual pathology website [44] is a valuable resource for students and professionals. It provides access to a vast collection of digital slides and cases, covering a wide range of pathological conditions. At the date of writing, the website hosts 239.6 TB of data comprising 591,091 individual WSIs, and has received 4,7 million page views in the last year. The site's user-friendly interface and high-quality images make it an excellent tool for self-directed learning and review. The recently launched PathologySearch.com provides a convenient search engine across this and other online WSI repositories.

Libre Pathology (librepathology.org) [45] is a collaborative initiative aimed at creating a free and open-access encyclopedia of pathology. It provides a wealth of comprehensive pathology content including over 3,000 illustrative images that are derived from the WikiCommons and may be modified/re-used under a creative commons license. It includes more than 2,800 content pages, and saw over 2.5 million visits in 2024 with up to 105,000 unique visitors per month. In addition to its extensive written materials, Libre Pathology features some multiple choice quizzes and 120 interactive cases categorized by difficulty and subspeciality. These are designed to simulate real-world scenarios, where users can progressively request more information until they are able to get to the diagnosis. Upon reaching a conclusion, users are directed to the full page dedicated to the diagnostic entity depicted in the case, which

Table II. Digital Pathology Resources Beyond Books

Resource	Type	Key Features	Access
Libre Pathology	Wiki + interactive cases	1,400 diagnoses, 3,000 CC-licensed images, quizzes, and WSI-based cases	Free, collaborative
drdoubleb.com	Interactive case platform	Simulates real-world diagnostics with IHC/FISH integration	Free, collaborative
PathPresenter	WSI repository + textbooks	35,000+ WSIs, annotated cases, side-by-side comparisons	Free/paid tiers
Virtual Pathology (Univ. Leeds)	WSI library	591,091 WSIs, organ-based modules	Free
PathologySearch	WSI search engine	Searches across other repositories such as Leeds and PathPresenter	Free
pathCast (YouTube)	Video lectures	Live seminars, subspecialty-focused content	Free

provides further details and educational insights.
In addition to dedicated websites and social media platforms, online video-sharing platforms like YouTube have become valuable resources for pathology education. Channels such as pathCast offer free access to a wealth of lectures on various pathology topics. PathCast specifically provides a wide library of videos ranging from cytopathology to surgical pathology, with contributions from experts in the field, providing an excellent opportunity for continuing education and in-depth study with the comfort of on-demand watching.
The influence of individual pathologists contributing to online education should also be acknowledged. People like Jerad Gardner are highly active on various social media platforms, including X and through creative initiatives like KiKo, effectively disseminating pathology knowledge to a broad audience. As highlighted by Cima et al. [40], Gardner is also a prolific author of scientific articles on the use of new technologies in pathology education, further demonstrating his commitment to advancing the field. His YouTube channel and social media presence offer insightful content, ranging from case discussions to educational videos, making complex topics more accessible and engaging.
To contribute to all this, platforms like PathPresenter [46] are designed specifically for sharing and discussing WSIs-a powerful tool for interactive pathology learning. This platform also provides free access to more than 35,000 WSIs encompassing every pathology subspecialty and a 'High Yield' section with hand-picked annotated cases. Furthermore, PathPresenter also hosts a section called "PathPresenter Publications", which hosts textbooks based heavily on WSIs paired with detailed explanations, clinical pictures, and extensive annotations. Additionally, it offers side-by-side comparisons of mimicking conditions, allowing users to better distinguish between similar pathological entities.
PathElective.com offers a structured and interactive learning experience. The platform provides free, high-quality pathology and laboratory medicine education at multiple levels of training. Its materials have been incorporated into medical student and resident training programs at numerous institutions, demonstrating its effectiveness. It utilizes quizzes to assess knowledge gain and identify areas where students may need additional support. Analyses of student usage data reveal a positive impact on learning outcomes, with participants demonstrating a significant increase in scores after completing courses [47-49].
These online resources represent a significant shift in pathology education, providing accessible, interactive, and engaging learning experiences. By leveraging these platforms, pathologists can stay updated on the latest advancements in the field, enhance their diagnostic skills, and participate in a global community of learners. Furthermore, these resources can be effectively integrated with traditional teaching methods, creating a blended learning approach that caters to diverse learning styles and maximizes educational outcomes.

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Conflicts of interest

AC, VL, and FF report ad-hoc advisory board membership with Roche Diagnostics Italia unrelated to the current work; FF is one of the inventors of "Sample imaging and imagery archiving for imagery comparison Merlo, P.T. et al. US patent 16/688/613 2020"; MB is the owner of Libre Pathology (https://librepathology.org) and known as "Nephron" on the WikiMedia Commons (https://commons.wikimedia.org/wiki/User:Nephron).The remaining authors have no conflicts of interest to declare.

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Author contributions

Manuscript-drafting: AC, GA, MF, AA. Manuscript-review and editing: all authors.
All authors critically revised the manuscript and agree with the final version to be published.

Ethical consideration

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