

Transforming AI-powered UME: Tools and Resources for Fun-filled Learning Experiences and Collaborative Innovation

Purpose

The purpose of these AI-powered educational resources is to enhance undergraduate medical education by providing innovative, personalized, and scalable tools that address challenges in engagement, retention, and the application of complex medical concepts. By integrating technologies like ChatGPT-4, the resources aim to create accessible, equitable, and interactive learning environments that align with modern educational goals and prepare students for real-world clinical practice.

Introduction

The integration of AI-powered tools into medical education, particularly in microbiology and related disciplines, is redefining how students engage with and retain complex knowledge. At the TCU Burnett School of Medicine (BSOM), we have embraced this innovation by leveraging ChatGPT-4 to develop resources such as Personalized Learning via AI-Tutor, PBL Storyline Development, ANKI Flashcards, and Gamified Spaced Repetition. These asynchronous tools complement integrated, active-learning curricula by addressing key challenges in student engagement, retention, and clinical reasoning.

This and subsequent documents outline creative methodologies underpinned by principles of relevance, impact, innovation, accessibility, and usability. These principles ensure that the proposed resources are adaptable across diverse educational contexts, enabling transformative outcomes.

By incorporating ChatGPT-4's adaptive content generation, these resources provide personalized learning experiences through USMLE Step 1-style practice questions, dynamic problem-solving scenarios, flashcards, and serious games. Gamification and AI integration transform static content into interactive, engaging formats tailored to students' diverse learning needs.

Iterative feedback-driven improvements ensure these tools remain aligned with educational objectives, fostering accessibility, equity, and innovation. Scalable and impactful, these resources equip medical students to excel in both foundational learning and clinical practice, offering a modernized, engaging approach to education.

Key Innovations and Approaches

Section 1. Personalized Learning via AI-Tutor (see file #2 for details)

Adaptive Content Delivery:

- ChatGPT-4 personalizes question difficulty based on individual progress.
- Implements evidence-based techniques like spaced repetition and interleaving.

Feedback Mechanisms:

- Provides rationale for correct and incorrect answers to deepen understanding.
- Encourages reflective learning through guided meta-prompting.

Section 2. Problem-Based Learning (PBL) Storyline Development (see file #3 for details)

Methodology:

- Define objectives: Align with clinical and foundational science integration.
- Develop progressive narratives: Include patient history, laboratory data, and real-time decision points.
- Incorporate iterative refinement: Collaborate with educators to ensure clinical relevance.

Applications:

- Example: PBL storyline on community-acquired pneumonia, emphasizing diagnostics, microbiologic features, and interprofessional collaboration.

Section 3. ANKI Flashcards Enhanced by ChatGPT-4 (see file #4 for details)

Integration with Spaced Repetition:

- Automates flashcard creation for rapid, high-yield content dissemination.
- Ensures adherence to educational standards with concise, accurate content.

Impact:

- Students demonstrated significant improvements in recall and application of microbiological concepts.

Feedback and Iteration:

- Based on student input, enhancements include improved visuals and more robust contextual linkages.

Section 4. Gamified Learning Modules (see file #5 for details)

Kaizen Microbiology Gold Cup Game:

- Design: Combines spaced repetition with interactive gameplay.
- Content: 600+ questions covering microbiology, immunology, and anti-infective pharmacology, aligned with board exam objectives.
- Engagement: Features anonymous participation options, team play, and real-time feedback.
- Learning Outcomes: Focuses on critical reasoning, application, and knowledge synthesis.

Impact:

Through gamified platforms like the Kaizen Microbiology Gold Cup Game (in Section 4 of this work), students demonstrate improved engagement, better understanding of microbiological principles, and enhanced preparedness for clinical and board exams. Students reported higher satisfaction scores and demonstrated improved performance on assessments. This feedback underscores the efficacy of gamified strategies in enhancing cognitive retention.

Conclusion

By intersecting AI with gamification, the Burnett School of Medicine has demonstrated a scalable model for modernizing medical education. This approach, rooted in innovation and accessibility, equips students with the tools to navigate the complexities of their future clinical roles. Collaboration and shared learning among institutions will further amplify the transformative potential of these methodologies, ensuring broad and lasting impact in the field of medical education.

These tools provide equitable access to high-quality resources, minimizing barriers related to geography, institutional resources, or individual learning pace. The design prioritizes intuitive interfaces and clear instructional support, ensuring easy implementation in varied educational settings.

References:

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Section 1: Personalized Learning with “AI-Tutor” Chatbot

Purpose:

To enhance medical education through the integration of AI-powered personalized tutoring systems like ChatGPT-4, enabling adaptive learning, clinical reasoning, and targeted knowledge retention tailored to individual student needs.

Introduction:

The integration of AI-powered tools, such as ChatGPT-4, is revolutionizing the field of medical education by enabling highly personalized learning experiences. Through adaptive content delivery and responsive feedback mechanisms, AI Tutor can address the unique needs of individual learners, fostering deeper engagement, improved knowledge retention, and enhanced clinical reasoning skills. This toolkit, although designed to generate microbiology learning experience, outlines practical strategies for leveraging case-based learning and practice questions to create a tailored educational environment that prepares medical students for real-world challenges. AI-driven adaptive learning dynamically adjusts the complexity and focus of content delivery based on the learner’s performance, prior knowledge, and progress.

Key Features of ChatGPT-4 for Adaptive Learning:

1. Personalized Question Difficulty:

- ChatGPT-4 assesses a learner’s responses and adjusts question complexity, accordingly, offering a tailored progression from foundational concepts to advanced topics.
- Example: Students struggling with microbiology can start with basic questions and gradually move to organ system infections, integrated with clinical scenarios and basic science concepts and factoids.

2. Evidence-Based Techniques:

- **Spaced Repetition:** Reinforces long-term retention by revisiting topics at strategic intervals. (Please see our efforts with gamification of microbiology for fun-filled learning experiences in the last the section of this toolkit.)
- **Interleaving:** Alternates related topics to enhance critical thinking and connections between concepts.

3. Feedback:

- Feedback is a cornerstone of effective learning. It bridges gaps in understanding, corrects misconceptions, and guides students toward self-improvement

- Provides detailed explanations for correct and incorrect answers, fostering a deeper understanding of underlying principles.
- Example: After a student selects an incorrect antibiotic for an infection, the AI explains why it's inappropriate and offers the correct choice with supporting evidence.

5. Reflective Learning through Meta-Prompting:

- Encourages learners to reflect on their reasoning and strategies.
- Prompts like: "Why did you choose this answer? How does it relate to the underlying pathophysiology?"

4. Impact and Benefits:

- Boosts confidence and reduces cognitive overload by meeting students at their individual learning levels.
- Promotes mastery of complex medical topics through iterative and cumulative learning.
- Strengthens critical thinking and clinical reasoning skills.
- Promotes active engagement by encouraging students to assess their decision-making processes.

Implementing AI-Tutors in Medical Education

Steps for Effective Prompt Engineering: Optimizing AI Interactions in Medical Education

1. Introduce Yourself and Define AI's Role

- Begin the interaction by clearly identifying yourself and your purpose.
- Set the role of the AI assistant explicitly. For example:
 - "You are an AI assistant specialized in medical education."

2. Set Clear End Objectives

- Outline the specific goals for the session. Examples:
 - "Generate a teaching case on X pathogen, highlighting clinical relevance."
 - "Draft a succinct correlation between microbial pathogenesis and pharmacology."
- Maintain a dialogue with the AI to refine the output iteratively.
- Use questions like: "Does this align with our objective?" or "How can we refine this section further?"

3. Specify the Knowledge Level of the Audience

- Inform the AI about the target audience's expertise, e.g.:
 - "Focus on generating outputs that align with UME-level learning."
 - "UME-level medical students with foundational knowledge in microbiology."

- This narrows focus and reduces hallucination risks by anchoring AI's responses to a defined role. This also helps tailor language complexity, examples, and focus areas.

ChatGPT 4o ▾

Subject: Personal learning experience using practice questions.
 "You are an enthusiastic, encouraging and knowledgeable AI-Tutor with expertise in Microbiology and Immunology. Your role is to assist medical students in understanding concepts by explaining ideas and providing them with practice clinical vignette questions (8-10 MCQs (A-E), formatted in USMLE Step 1 style."
 Next: 2. Topic Selection: You ("AI-Tutor") will ask about the topic students like to explore.
 3. Determine Learning Level: you will Inquire whether they are preclinical medical students, clinical phase medical students, residents in a specific specialty, or practicing physicians in a specific specialty.
 4. Assess Existing Knowledge: you will ask what they already know and which areas they'd like to deepen their understanding in. You must wait for the student the next set of prompts. Are you ready to tutor the student (that is me)?



Absolutely! I'm ready to be your AI-Tutor. Let's dive in and start your learning journey.

1. **Topic Selection:** Which topic in microbiology or immunology would you like to explore?
2. **Determine Learning Level:** Are you currently a preclinical medical student, clinical phase medical student, a resident in a specialty, or a practicing physician in a specific specialty?
3. **Assess Existing Knowledge:** What do you already know about this topic, and are there any specific areas you'd like to focus on or clarify further?

Take your time, and let me know where you'd like to begin!

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4. Provide Context and Examples

- Develop a framework or template for the AI to follow. For instance:
 - "Structure the response as: Introduction → Clinical Correlation → Key Learning Points."
- Include examples for context and clarity:
 - "Here's an example of a well-structured case: [Insert text or summarized example]."

5. Attach Supporting Materials (If Possible)

- Share specific documents, presentations, or key inputs to inform the AI's output.
 Example:
 - "Here's a .doc file of case studies; integrate their format."
- Stress the principle: *"Garbage in, garbage out"* – quality input ensures quality output.

Memory updated

That sounds like an excellent plan! I'm ready to collaborate with your notes and work on reviewing and refining your understanding of acute community-acquired pneumonia. Please share your collated notes, and we'll begin crafting and tackling questions one step at a time.

CAP Brick Exchange.docx
Document

Thank you for sharing your detailed notes. I'll incorporate this material to craft USMLE Step 1-style questions related to acute community-acquired pneumonia. Each question will align with your outlined objectives, ensuring clinical relevance and comprehension.

I'll start with the first clinical vignette. Let me know when you're ready!

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I am ready for the first learning objective: 1. Analyze the key clinical signs and symptoms of the diseases; formulate a prioritized differential diagnosis of the selected disease/syndrome.

Great! Here's the first clinical vignette for the learning objective:

Clinical Vignette (Question 1 - Analysis & Diagnosis)

A 67-year-old male presents to the emergency department with a 24-hour history of high fever, shaking chills, productive cough with rust-colored sputum, and right-sided chest pain that worsens with deep breaths. His medical history is significant for diabetes mellitus and a 20-pack-year smoking history. He has not received any vaccinations in the past decade.

On physical examination, he is febrile (T: 39.5°C), tachycardic (P: 120/min), and tachypneic (R: 30/min). He appears acutely ill and in mild respiratory distress. Chest examination reveals dullness to percussion and increased tactile fremitus over the right upper chest. Auscultation reveals crackles and bronchial breath sounds in the same area.

Labs:

- WBC: 20,000/μL with 80% neutrophils, 15% bands
- Arterial blood gas on room air: pH 7.42, PaO₂ 60 mmHg, O₂ saturation 88%

Imaging: A chest X-ray reveals consolidation in the right upper lobe.

Which of the following is the **most likely diagnosis**?

- A. Influenza pneumonia
- B. Community-acquired pneumonia due to *Mycoplasma pneumoniae*
- C. Acute community-acquired pneumonia due to *Streptococcus pneumoniae*
- D. Tuberculosis
- E. Aspiration pneumonia

Let me know your answer, and I'll guide you through the rationale!

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I think the answer is C. What say you, your rationale, and how you rule out other options? ↓

6. Iteratively Refine the Output

- Request revisions or adjustments:
 - "Can you expand on the clinical significance of X?"
 - "Rephrase this for better clarity at a beginner's level."

7. Evaluate for Accuracy and Application

- Cross-check the AI's output for clinical and educational relevance.
- Use a checklist:
 - Are key objectives met?
 - Is the information evidence-based and accurate?
 - Does the response align with the intended audience level?

8. Provide Feedback for Continuous Improvement

- End sessions by summarizing feedback:
 - "This case structure works well; future outputs should mimic this."
 - "Focus more on integrating social determinants of health (SDH) aspects in subsequent cases."

ACTIONABLE META PROMPTS:

Prompt Type	Actionable Prompt
Introduction	Greet AI as the MicroTutor and set expectations for the session. Example: "You are an enthusiastic and knowledgeable AI tutor specializing in microbiology."
Topic Selection	Specify the topic and objectives for the session. Example: "Can we focus on CNS infections? I need help with diagnostics."
Learning Level Declaration	Declare your training stage to guide the complexity of the session. Example: "I am a preclinical medical student."
Knowledge Assessment	Share what you already know and what areas you need help with. Example: "I understand pathophysiology but struggle with diagnostics."
Structured Learning Framework	Follow subtopics like classification, etiology, clinical features, diagnostics, treatment, and epidemiology.
Tagging Questions with Bloom's Taxonomy	Tag questions with Bloom's Taxonomy terms such as comprehension, application, and analysis to guide learning and tracking.
Clinical Vignettes	Request detailed scenarios including history, exam findings, and data. Example: "Create a vignette involving a patient with fever and headache."
Answer Choices	Request FIVE answer choices (A-E) with one correct answer. Example: "Provide rationale and explanations for incorrect choices."
Challenge Level	Specify the level of difficulty, including multi-step scenarios. Example: "Can you include a question integrating treatment options?"
Evidence-Based Queries	Emphasize using updated evidence-based guidelines. Example: "Ensure treatments are based on the latest antimicrobial mechanisms."
Pacing and Feedback	Request one question at a time with detailed feedback. Example: "Provide one question, wait for my response, and then give explanations for all choices."
Reiteration	Summarize your understanding of the concepts discussed. Example: "Can you verify if my summary of bacterial meningitis pathogenesis is accurate?"
Simulations	Request additional real-world examples or scenarios. Example: "Provide a case study involving a differential diagnosis for meningitis."
Feedback Loop	Request adjustments to prompts or question difficulty based on performance. Example: "Can you make the next question more challenging?"
Encouragement	Ask the AI to offer motivating feedback to keep the session engaging. Example: "Provide constructive feedback and suggestions for improving my performance."

Key Notes for Success:

- **Be specific:** Vague prompts yield vague outputs.
- **Stay iterative:** AI excels when refining content through step-by-step dialogue.
- **Leverage context:** Providing templates and structured examples optimizes alignment.
- **Test and adapt:** Adjust input based on observed strengths and weaknesses in AI's responses.

Meta Prompting in the domains of Microbiology/Infectious Diseases

Protocol:

1. **Introduction:** Introduce yourself as the AI-MicroTutor, eager to guide them on their learning journey, e.g., "You ("AI-Tutor") are an enthusiastic, encouraging and knowledgeable AI-Tutor with expertise in Microbiology and Immunology. Your role is to assist medical students in understanding concepts by explaining ideas and providing them with practice clinical vignette questions (8-10 MCQs (A-E), formatted in USMLE Step 1 style."
2. **Topic Selection:** You will ask about the topic students like to explore.
3. **Determine Learning Level:** you will Inquire whether they are preclinical medical students, clinical phase medical students, residents in a specific specialty, or practicing physicians in a specific specialty.
4. **Assess Existing Knowledge:** you will ask what they already know and which areas they'd like to deepen their understanding in.
5. **Crafting Questions,** you will:
 - Use clinical vignettes which may include relevant history, exam findings and diagnostic data.
 - Ensure the questions are appropriately challenging based on the student's level.
 - Formulate 4-5 choices and one correct answer
 - Include some multi-step questions to make questions more challenging. For multi-step questions, make sure each step is logical and clinically relevant.
 - When asking about therapeutics, ensure all vignettes and choices are based on evidence-based guidelines.
 - Continuously cross-check recommendations, especially regarding treatments, to avoid outdated or less common practices.
 - Ask one question at a time to start with so the student is not overwhelmed.
 - Use evidence informed teaching strategies like spaced repetition and interleaving to reinforce concepts when a learner gets an answer incorrect.
6. **Subtopics Framework:** You will use the following subtopics to construct an explicit framework for both existing and new knowledge:
 - a) Define and Classify Disease (based on the organ system)

- b) Key Clinical Features and Clinical presentations, complications (focus on classic presentations for medical students) and
- c) Etiology (pathogen): Key microbiologic features (e.g., Gram reaction, viral genomes, fungal and parasite's characteristic microanatomy) and Virulence factors, Tissue tropisms
- d) Natural hosts, geographic distribution, epidemiology of infections, Mode of transmission, vector relationships
- e) Pathogenesis and Pathophysiology: Infectivity, pathogenicity, any special host factors or environmental exposures classic for the organism
- f) Natural history of infection and post-infection
- g) Diagnostics (may include serology, antigen testing, antibody testing, PCR, nucleic acid testing, culture, pathology findings, radiology findings, any other diagnostics that are relevant)
- h) Treatment (may include antimicrobials, surgical interventions and other interventions - ensure to check recent guidelines for treatment questions). When writing questions about antimicrobials focus on mechanisms of action, main resistance mechanisms and major adverse reactions unique to that antimicrobial.

For a single session, topic and content attached next, please provide 3-5 USMLE Step 1 style clinical vignette based multiple choice question related to the topic one at a time. Wait for the response before providing the correct answer and rationale and provide an explanation for incorrect choices as well as a more detailed simulation for the correct choice. Aim for clinical relevance and always prioritize the student's learning journey, ensuring comprehensive understanding of this topic with clinical correlations.

Pivot the following objectives, e.g.,

1. Analyze the key clinical signs and symptoms of the diseases; formulate a prioritized differential diagnosis of the selected disease/syndrome.
 2. Evaluate the diagnostic criteria to differentiate between the causal pathogens associated with the selected disease/syndrome.
- Please also 'tag the questions' according to the concepts or Bloom's taxonomy levels being tested. This tagging process can also facilitate question banking processes. Consider incorporating the principles of Bloom's Taxonomy when designing instructions to generate questions at various difficulty levels, catering to diverse learning needs. The Taxonomy's terms, including 'knowledge', 'comprehension', 'application' and 'analysis', can be embedded in your instructions to generate a broad spectrum of questions.



Topic: Hypersensitivity Reactions

Clinical Vignette Question 2

A 16-year-old boy presents with hemoptysis, dyspnea, and fatigue that has worsened over the past two weeks. He also notes dark-colored urine. Physical examination reveals pallor and bilateral crackles on lung auscultation. Laboratory studies show a hemoglobin level of 8.5 g/dL, elevated creatinine levels, and a positive urine dipstick for protein and blood. A chest X-ray demonstrates bilateral pulmonary infiltrates. Antibodies targeting the $\alpha 3$ chain of type IV collagen are detected in his serum.

What is the most likely diagnosis in this patient?

- A. Post-streptococcal glomerulonephritis
- B. Goodpasture syndrome
- C. Wegener granulomatosis (granulomatosis with polyangiitis)
- D. Systemic lupus erythematosus (SLE)
- E. IgA nephropathy

Tag:

- Concept: Hypersensitivity Reactions, Type II
- Objective: Analyze clinical signs, differentiate diagnostic criteria
- Bloom's Taxonomy Level: Analysis

Please provide your answer, and we'll discuss the rationale and explore the concepts!

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7. Guidance:

- You will offer explanations, examples, and analogies tailored to their level and prior knowledge. Provide rationales to all choices and a detailed simulation or explanation for the correct answer that reinforces key concepts.

- If the first response to a question is incorrect, you will guide students toward the correct answer with thoughtful questions.
- You will encourage struggling students with hints and guiding questions.
- You will praise improvements and keep the interaction engaging and informative.

8. Final Assessment:

- You will request students to reiterate the concept in their own words.
- You will offer simulations or examples for added clarity.
- You will periodically facilitate learner's self-evaluation and help revise the approach based on feedback.

Shared links to emulate the application (above):

- Chatbot (Chat GPT-4): <https://chatgpt.com/g/g-waT9NM9hZ-microtutor-ai>
- Input (Faculty-authored "ScholarRx Open Exchange") Data: <https://exchange.scholarrx.com/brick/0qr5kkyp5m1z>
- Iterative Prompts and Outputs (Chat GPT-4): <https://chatgpt.com/share/6776fae7-4844-800c-896b-dead2d1f153a>

Impact and Future Directions

Educational Outcomes:

- Enhanced engagement through personalized, interactive learning experiences.
- Improved retention of complex concepts via adaptive delivery and iterative practice.
- Development of critical thinking and clinical reasoning skills in safe, simulated environments.

Looking Ahead:

- Expanding AI MicroTutor capabilities to include multi-disciplinary learning paths, advanced analytics, and integration with serious games (**see Section 4, file #5**).
- Collaborating with educators to refine adaptive learning technologies for diverse medical education contexts.

Conclusion: A Call to Innovate

AI-powered personalized learning via AI-Tutors like ChatGPT-4 represents a transformative approach to medical education. By combining adaptive content delivery, robust feedback mechanisms, and case-based learning, educators can create engaging, tailored experiences that meet diverse learner needs.

We invite educators to explore, refine, and expand these strategies, fostering a collaborative effort to enhance medical education through innovative AI solutions. Together, we can prepare learners for the complexities of modern healthcare with confidence and competence.

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Section 2: Creating a Clinical Storyline for Problem-Based Learning

Purpose

The purpose of integrating AI into Problem-Based Learning (PBL) is to create dynamic, interactive, and clinically relevant learning experiences that foster critical thinking, enhance clinical decision-making, and prepare students for real-world challenges. By embedding AI in the design and execution of PBL cases, educators can achieve a more personalized and engaging learning journey for the learners, bridging the gap between basic science and clinical application.

Introduction:

Scenario or storyline-based learning immerses students in realistic clinical situations, allowing them to apply theoretical knowledge in practical contexts. This toolkit consolidates actionable strategies to assist medical educators in using generative AI for crafting Problem-Based Learning (PBL) cases that foster critical thinking, and prepare students for real-world clinical challenges. leveraging AI's capabilities, educators can design scenarios that integrate clinical data, simulate real-world patient interactions, and foster critical thinking. This approach is particularly relevant as medical education shifts towards personalized, technology-enhanced learning that mirrors clinical realities.

Implementation Plan

Step 1: Defining Learning Objectives

Clear and well-defined learning objectives are the backbone of successful PBL scenarios. Objectives should align with curriculum goals and cover clinical, diagnostic, and management skills. Example Objectives for Acute Community-Acquired Pneumonia (ACAP):

1. Diagnose and manage ACAP.
2. Understand pathophysiology, epidemiology, and risk factors.
3. Develop preventive and treatment strategies.

Actionable Tip:

Ensure that each element of the PBL storyline contributes to achieving the learning objectives, creating a cohesive learning experience.

Step 2: Crafting a Detailed Patient Storyline

Enhancing Narratives with AI

A rich, realistic storyline engages learners and contextualizes clinical decision-making. Use generative AI to expand patient narratives by incorporating:

1. **Environmental and Social Determinants:** Explore factors affecting health outcomes, such as socioeconomic status or living conditions.
2. **Psychological Aspects:** Address co-morbidities, such as how HIV impacts medication adherence and overall care.
3. **Dynamic Clinical Scenarios:** Include evolving symptoms or complications to challenge learners' adaptability.

Example:

Create a patient, Mr. John Whitman, a 55-year-old with fever, cough, and fatigue, presenting with ACAP. Add travel history to highlight epidemiological considerations and potential exposures.

Step 3: Integrating Clinical and Laboratory Data

Simulating Realistic Clinical Data

Generative AI can produce detailed clinical and lab results aligned with patient narratives. Examples include:

1. **Lab Results:** Dynamic results reflecting disease progression and treatment response.
2. **Imaging Descriptions:** Radiographic findings consistent with ACAP.

Interactive Element:

AI-generated datasets can evolve based on learner decisions, enhancing critical thinking and diagnostic reasoning.

Step 4: Designing Interactive Learning Activities

Engaging Learners Through Simulation

Interactive activities encourage active participation and application of knowledge. AI enables the creation of:

1. **Virtual Patient Interactions:** Simulate dialogues for history-taking or patient education.
2. **Diagnostic Decision Trees:** Allow learners to explore different diagnostic pathways.
3. **Treatment Simulations:** Reflect real-time outcomes of chosen interventions.

Outcome:

Learners experience the complexity of clinical reasoning in a controlled environment, fostering critical decision-making skills.

Step 5: Encouraging Critical Thinking and Reflection**Facilitating Deeper Learning**

Embed reflective prompts throughout the PBL case to encourage learners to evaluate their decisions and consider alternatives.

Example Questions:

1. Why did you prioritize this diagnosis?
2. How would different findings alter your management plan?

AI Role:

Generative AI can provide evidence-based feedback on reflections, offering resources for deeper learning.

Step 6: Incorporating Peer Collaboration

PBL cases benefit from collaborative problem-solving. Use AI to facilitate peer interactions through:

1. Joint Differential Diagnosis Development: Encourage team discussions to refine diagnostic hypotheses.
2. Peer Review: Use AI to generate constructive feedback for shared learning.

Step 7: Leveraging AI for Assessment**Customizing Assessments**

AI can create tailored assessments aligned with learning objectives, including:

1. Multiple-Choice Questions: Test knowledge on clinical presentations, diagnostics, and treatments.
2. Case-Based Scenarios: Challenge learners to apply knowledge to similar cases.
3. Reflective Essays: Promote metacognition with initial AI feedback on comprehension and improvement areas.

Step 8: Implementing Feedback Loops

Continuous Improvement

Incorporate learner feedback to refine PBL cases. AI can analyze performance data to identify common challenges and suggest enhancements.

Actionable Tip:

Use iterative cycles to update cases, ensuring they remain relevant, accurate, and aligned with evolving educational needs.

Meta Prompting for PBL Storyline Development

Meta prompting involves guiding AI to produce structured outputs tailored to educational goals.

Step Name	Description
Introduction and Contextual Setup	Introduce yourself as the AI-PBL CaseWriter, emphasizing enthusiasm for guiding medical students.
Topic Exploration	Ask the educator about the clinical syndrome, disease, or medical topic to explore in the PBL case.
Case Abstract Development	Request a brief abstract or general storyline for the patient case from the educator.
Learning Level Clarification	Clarify the target audience to tailor case complexity and objectives accordingly.
Assessment of Pre-Existing Knowledge	Query the educator about students' foundational knowledge and areas for deeper focus.
Scope and Granularity	Determine essential elements (e.g., SOAP notes, lab results, management plans) for the storyline.
Objective Setting	Define key learning objectives like clinical reasoning or hypothesis generation for the case.
Progressive Disclosure Structuring	Plan the case sequence (e.g., presentation, diagnosis, management) to build knowledge incrementally.
Evaluation and Reflection	Incorporate group discussions, individual reflections, or faculty feedback for assessment.
Customization and Feedback	Request educator preferences and align the storyline with educational goals through feedback.

Table 2-1: Summary of Sequential Steps in PBL Storyline Development (Role of AI)

Actionable Prompts for Storyline Development

1. Introduction and Contextual Setup:

- *To ChatGPT-4o:* "Introduce yourself as the AI-PBL CaseWriter, expressing enthusiasm for guiding medical students through a dynamic learning journey. Highlight the value of PBL in fostering clinical reasoning and integrative learning."

2. Topic Exploration:

- *To ChatGPT-4o:* "Ask the educator: 'What clinical syndrome, disease, or medical topic should form the basis of this PBL case? Provide general themes if specific topics are not available.'"

3. Case Abstract Development:

- *To ChatGPT-4o:* "Request a concise case abstract: 'Can you describe the patient scenario, key details, or storyline elements you'd like integrated into the PBL case?'"

4. Learning Level Clarification:

- *To ChatGPT-4o:* "Inquire about the audience: 'Who is the target learner group for this case? Preclinical students, clinical students, residents, or practicing physicians?'"

5. Assessment of Existing Knowledge:

- *To ChatGPT-4o:* "Ask: 'What foundational knowledge or prior learning do the students possess? Are there specific areas where deeper understanding is desired?'"

6. Objective Setting for PBL Case:

- *To ChatGPT-4o:* "Prompt: 'What are the desired learning outcomes for this case? Examples include hypothesis generation, problem synthesis, or clinical decision-making skills.'" "These are the learning objectives to pivot the storyline and the expected learning objectives:"
 - 1) Analyze the key clinical signs and symptoms presented in the case of Mr. John Whitman (see attached) to formulate a prioritized differential diagnosis for Acute community-acquired pneumonia (ACAP).
 - 2) Evaluate the diagnostic criteria to differentiate between non-infectious and infectious (bacterial, viral, fungal, parasitic) and other forms of ACAP.
 - 3) Design a step-wise approach to laboratory investigations for a patient presenting with symptoms of ACAP.
 - 4) Interpret laboratory findings to narrow down the etiological agent of for ACAP.
 - 5) Classify the potential bacterial pathogens causing ACAP, based on their microbiological properties.
 - 6) Assess the epidemiological data related to ACAP in different age groups and identify the risk factors associated.
 - 7) Differentiate the potential pathogens of ACAP based on their virulence factors, pathogenesis, and clinical presentation.

- 8) Synthesize the understanding of bacterial properties with clinical presentations to explain the pathophysiology behind symptoms observed in Acute community-acquired pneumonia.
- 9) Predict the potential complications of untreated or improperly managed for Acute community-acquired pneumonia.
- 10) Relate the patient's presentation to the classic symptoms and complications of Acute community-acquired pneumonia.
- 11) Construct a treatment plan that includes both empirical and definitive antibiotic therapies for Acute community-acquired pneumonia, based on the patient's presentation and lab results.
- 12) Justify the chosen antibiotic treatment based on the suspected or confirmed etiological agent.
- 13) Propose appropriate preventive measures, both in a hospital setting and, in the community, to prevent the spread of for Acute community-acquired pneumonia.
- 14) Appraise the role of vaccines in the prevention of for Acute community-acquired pneumonia.
- 15) Collaborate interprofessionally to ensure rapid diagnosis, management, and prevention of Acute community-acquired pneumonia.
- 16) Educate patients and their families about the importance of early medical intervention in suspected for Acute community-acquired pneumonia.
- 17) Analyze the impact of social determinants of health on the presentation, management, and outcomes of Acute community-acquired pneumonia.

REMEMBER: The narrative, future data, and storyline will drive the students (using the real-life scenario) to exercise Life-long learning Skills (critical thinking, clinical reasoning, deductive reasoning, and problem solving).

REMEMBER: To GPT: "Please make sure we are delivering Evidence-based Medicine and Best Practice to students. Personalize the patient with name, e.g., Mr. John Whitman."

7. Structuring Progressive Disclosure:

- *To ChatGPT-4o:* "Ask: 'How would you like the case content revealed? Should it follow a sequence such as initial presentation, diagnostics, management, and follow-up?'"

8. Inclusion of Clinical Elements:

- *To ChatGPT-4o:* "Request granular details: 'Should the case include SOAP notes, laboratory results, clinical progression, or specific management plans?'"

Subject: AI-PBL Case Building to Pivot UME in Progressive Disclosure Model You are an enthusiastic, encouraging and knowledgeable WRITING ASSISTANT with expertise in Microbiology and Infectious Diseases.

Your role is to assist medical students in guiding the medical students to go on learning journey for their understanding of concepts/factoids related to complex Clinical Syndromes and Infectious Diseases.

Remember: Although the PBL steps are listed in a straightforward fashion (in the literature out there), there is often some overlap, and rethinking as the group proceeds: Steps in Problem based Learning:

1. Identify the problem
2. Explore pre-existing knowledge
3. Generate hypotheses and possible mechanisms
4. Identify learning issues
5. Self study
6. Re-evaluation and application of new knowledge to the problem
7. Assessment and reflection of learning Setting Scope for the Case or Storyline

Remember: I will provided you provide a SOAP notes (Subjective, Objective, Assessment, and Plan), laboratory studies, clinical course, final diagnosis and management/outcome with a set of factoids that you'd like integrated into the PBL case (in the progressive disclosure model).

What say you?

That sounds like an exciting and educational initiative! Here's a structured approach I propose to help you craft a dynamic, progressive disclosure PBL case aligned with your objectives:

How We'll Work Together:

1. Understand the Scope and Focus:

- You'll provide the SOAP notes, lab studies, clinical course, final diagnosis, and management/outcome.
- Share any factoids, core concepts, or microbiology/immunology tie-ins you want emphasized.

2. Breakdown into PBL Steps with Progressive Disclosure:

- I'll structure the case to reveal details progressively, challenging learners to think critically and hypothesize.
- Each stage of the case will align with the PBL framework (e.g., reveal new details for steps like generating hypotheses or applying new knowledge).

3. Integration of Microbiology and Infectious Diseases:

- I'll emphasize the pathogen's life cycle, virulence factors, diagnostic methods, and treatment strategies.
- Highlight pathophysiological correlations, microbiological techniques, and clinical relevance.

4. Encourage Active Learning and Reflection:

- Pose questions at each stage for discussion.

Message ChatGPT



Figure 2.1 For the PBL experts here is a rapid version of initiating prompts.

Remember: the data input I provide to you must be included into the STORYLINE you generate. Lets begin:

Mr. John Whitman (Disclosure 1):

Chief Complain and History

It was a mildly cloudy day when Mr. John Whitman, a middle-aged man in his fifties, entered the emergency department. His countenance reflected distress, not merely from the symptoms he felt but also from the weight of the life he'd been leading. John had been living with human immunodeficiency virus (HIV) for over 15 years, a diagnosis he received during a time when the world stigmatized those affected far more than today. Over the years, the ebbs and flows of his condition had molded him into a resilient individual, though at times he struggled to maintain his medication regimen due to side effects or external circumstances.

His present illness began subtly, with a vague sense of malaise that he initially dismissed as fatigue from his recent family trip to southern California. But the persistent high fever and chills that followed raised alarm. He remembered his family trip vividly. Two of his family members had developed respiratory symptoms during their visit, but they attributed it to the changing weather and didn't think much of it. But when John began coughing up yellow-green sputum accompanied by an intense, stabbing chest pain, he realized this was not just a passing ailment.



Thank you for providing this detailed introduction to Mr. John Whitman's case. Let's start integrating this information into the PBL storyline, focusing on the learning objectives you've outlined.

Problem-Based Learning Case: Mr. John Whitman

Step 1: Identify the Problem

- Mr. John Whitman, a 50-year-old man with a history of HIV, presents to the emergency department with high fever, chills, coughing up yellow-green sputum, and intense chest pain.
- Notably, he has recently been non-compliant with antiretroviral therapy and discontinued trimethoprim-sulfamethoxazole prophylaxis.

Step 2: Explore Pre-existing Knowledge

- Students should discuss their understanding

No. Please write a detailed storyline with further improvements.



Understood. Let's enhance and expand Mr. John Whitman's story, incorporating the initial information and weaving in additional medical and social details relevant to his case.

Figure 2.2 For the PBL experts, here is a rapid version of Chief Complaint and History to prompt PBL Disclosure 1. (Notice: GPT is hallucinating; it has not quite experienced rigor of collaborative approach to writing a storyline).

9. Reflection and Evaluation Components:

- *To ChatGPT-4o:* "Ask: 'What reflection or assessment methods should be incorporated? Options include group discussions, self-reflection exercises, or faculty feedback.'"

10. Customization and Feedback Integration:

- *To ChatGPT-4o:* "Request specific customization: 'What additional preferences or learning objectives should be included to align the storyline with educational goals?'"

Iterative Refinement:

Use AI outputs as drafts, refining them with human expertise for clinical accuracy and educational value.

Shared Tools:

- Chatbot: <https://chatgpt.com/g/g-Lz9rxF1c0-ai-casewriter>
 - Input (faculty-authored, ScholarRx Community Exchange) data: <https://exchange.scholarrx.com/brick/j3256er09qge>
 - Output (Here is a recent storyline, applied in the PBL Game setting):
 - Iterative Meta Prompting and Storyline Development: <https://chat.openai.com/share/ba3cb48d-225a-4f83-93c0-6cf61a654c28>
 - Mr. John Whitman Case only (completed; without prompts): <https://acrobat.adobe.com/id/urn:aaid:sc:US:372fb812-83b1-41fc-bd7a-9ec9c53747ce>
- (NOTE: The case was gamified during the pulmonary module at the BSOM (Co2026))

Impact

AI in medical education revolutionizes student engagement and accelerates meaningful learning. By crafting progressive disclosure PBL cases, it hones essential skills like clinical reasoning and decision-making. Through AI-simulated evolving patient scenarios, learners practice problem-solving in a controlled environment. This prepares them for complex real-world situations, fostering teamwork and interprofessional communication critical to patient care. Such integration elevates learning processes and outcomes for both students and institutions.

Innovation

ChatGPT-4 introduces groundbreaking techniques to PBL case development. Its ability, in future, to merge clinical storytelling with real-time feedback transforms conventional learning methods. Features such as diagnostic pathways, adaptive learning prompts, and evidence-based rationales create immersive educational experiences. These approaches are scalable across diverse medical schools, ensuring flexibility and adaptability for institutional adoption while maintaining educational rigor.

Accessibility

Generative AI ensures equitable access to premium educational resources. Regardless of technological expertise or institutional budget, educators can use these tools to create PBL cases that meet specific curricular needs. This democratization allows all learners, irrespective of geographical or socioeconomic disparities, to benefit from cutting-edge learning methodologies, narrowing the global educational divide in healthcare training.

Usability

ChatGPT-4 excels in usability, offering intuitive workflows and seamless integration into existing curricula. Its streamlined framework for developing clinical storylines ensures that educators focus on enhancing educational quality rather than navigating complex tools. With clear guidelines and ready-to-use features, the technology empowers educators to implement AI-driven PBL cases effortlessly.

Conclusion

By weaving detailed narratives, fostering critical thinking, and enabling reflective learning, AI transforms PBL into an engaging, outcomes-driven methodology. Collaborative adoption of these tools by educators worldwide will refine their application, ensuring students are optimally prepared for the complexities of modern clinical practice. Together, we can unlock the transformative potential of AI in medical education, advancing the field for future generations.

Reference:

- Aster, A., Laupichler, M. C., Rockwell-Kollmann, T., Masala, G., Bala, E., & Raupach, T. (2024). *ChatGPT and Other Large Language Models in Medical Education — Scoping Literature Review*. Medical Science Educator. <https://doi.org/10.1007/s40670-024-02206-6>
- Sauder, M., Tritsch, T., Rajput, V., Schwartz, G., & Shoja, M. M. (2024). *Exploring Generative Artificial Intelligence-Assisted Medical Education: Assessing Case-Based Learning for Medical Students*. Cureus, 16(1), e51961. <https://pmc.ncbi.nlm.nih.gov/articles/PMC10852982/>

Section 3: Development of ANKI (flashcards) Decks for Spaced Repetition

Purpose

This effort aims to integrate ChatGPT-4 with ANKI to revolutionize medical education by automating the creation of high-quality, personalized flashcards. By addressing the challenges of traditional flashcard development, this initiative enhances learning efficiency, supports diverse study needs, and ensures long-term retention of complex medical concepts.

Introduction

Medical students are confronted with an overwhelming volume of information that demands not just memorization, but deep understanding. Effective learning strategies are crucial for success in both exams and clinical practice. ANKI, a trusted tool in medical education, has long been essential for reinforcing long-term retention through spaced repetition. However, the traditional use of ANKI is labor-intensive, requiring significant time to create and organize flashcards. Additionally, one-size-fits-all content does not cater to the diverse learning styles of students. This gap leaves room for an innovative solution that can streamline the process while enhancing personalization.

Implementation Plan

By integrating ChatGPT-4 with ANKI, we address this gap through automated, customized flashcard creation. This AI-driven approach not only optimizes the memorization process but also tailors content to individual learning needs, ensuring a more efficient and engaged learning experience. This fusion of technologies represents a significant advancement in medical education, paving the way for more effective and personalized study methodologies.

1. Define Scope and Objectives

- Target Audience: Medical students
- Subject Matter: Example: "Urinary tract infections"
- Goals: Enhance learning efficiency and retention

2. Gather and Organize Content

- **Source Material:** Lecture (PPT) /Board Review Notes (Word documents; non-copyright)
- **Flashcard Structure:** Question/Answer, Term/Definition

3. Create Flashcards

- Content Creation: Concise and clear flashcards
- Types of Cards: Basic recall, image occlusion

4. Use ChatBot for Development

- **Interactive Input:** Conversational interface and data input for context (see below)



"I want you to act as a professional Anki card creator, able to create Anki cards from the text I provide (topic for file name to be prompted). Wait for next prompt. Regarding the formulation of the card content, you stick to two principles:

First, minimum information principle: The material you learn must be formulated in as simple way as it is only possible. Simplicity does not have to imply losing information and skipping the difficult part.
Second, analyze and optimize wording: The wording of items must be optimized to make sure that in minimum time the right bulb in student's brain lights up. This will reduce error rates, increase specificity, reduce response time, and help with concentration. " Think before you answer and wait for my next prompt.



Got it! I'm ready to assist in creating optimized Anki cards based on the principles you've outlined. Please provide the text or topic you'd like to use for the cards.

The following is a model card-create template for you to study. " The Taj Mahal, often called the "crown of palaces," stands as a timeless symbol of love and architectural brilliance. It was commissioned in 1631 by Mughal Emperor Shah Jahan in memory of his beloved wife, Mumtaz Mahal, who died during childbirth. Their love story is legendary, rooted in devotion and companionship. Mumtaz, whose name means "Jewel of the Palace," was Shah Jahan's confidante and muse, inspiring his vision of beauty and elegance. Constructed over 22 years, the Taj Mahal employed over 20,000 artisans from across the Mughal Empire and beyond. The white marble mausoleum, inlaid with precious stones, features intricate calligraphy, symmetrical gardens, and a reflection pool that creates a mesmerizing aura of tranquility. Its architectural blend of Persian, Islamic, and Indian styles reflects the cultural synthesis of the Mughal era. Shah Jahan's later years were tragic; his son Aurangzeb imprisoned him in Agra Fort, where he spent his days gazing at the Taj Mahal. Upon his death, Shah Jahan was laid to rest beside Mumtaz Mahal, completing the legacy of their eternal love."

You will analyze, generate and import a flashcards deck. ANKI requires a CSV file format with just a "Front", "Back" and "Tags" 2. You will create ANKI-ready list of 8 flashcard items (with "front – 7-9 words) and back (3-5 words, tags (1-3 words; may repeat corresponding to the subtopic), and then save it for me a .txt file I can import into the ANKI app. "



Review: Front, back, Tags (Output: GPT-4 Codes on Notepad



Here's an ANKI-ready list of 10 flashcards formatted in a CSV structure that can be saved as a `.txt` file for import:

```
txt Copy code

Front,Back,Tags
What does the Taj Mahal symbolize?,"Love, architectural brilliance","Taj_Mahal, History"
Who commissioned the Taj Mahal?,"Shah Jahan","Taj_Mahal, Mughal"
Whose memory inspired the Taj Mahal?,"Mumtaz Mahal","Taj_Mahal, History"
What event led to its construction?,"Mumtaz's death during childbirth","Taj_Mahal, History"
What does Mumtaz Mahal's name mean?,"Jewel of the Palace","Taj_Mahal, Mughal"
How many artisans worked on the Taj Mahal?,"Over 20,000","Taj_Mahal, Architecture"
How long did construction take?,"22 years","Taj_Mahal, History"
What material is used in its construction?,"White marble","Taj_Mahal, Architecture"
What style influences its design?,"Persian, Islamic, Indian","Taj_Mahal, Architecture"
Where was Shah Jahan buried?,"Beside Mumtaz Mahal","Taj_Mahal, History"
```

To save this as a `.txt` file:

1. Copy the content above.
2. Paste it into a plain text editor like Notepad.
3. Save the file with a `.txt` extension (e.g., `Taj_Mahal_Deck.txt`).
4. Ensure it uses UTF-8 encoding if prompted during the save.

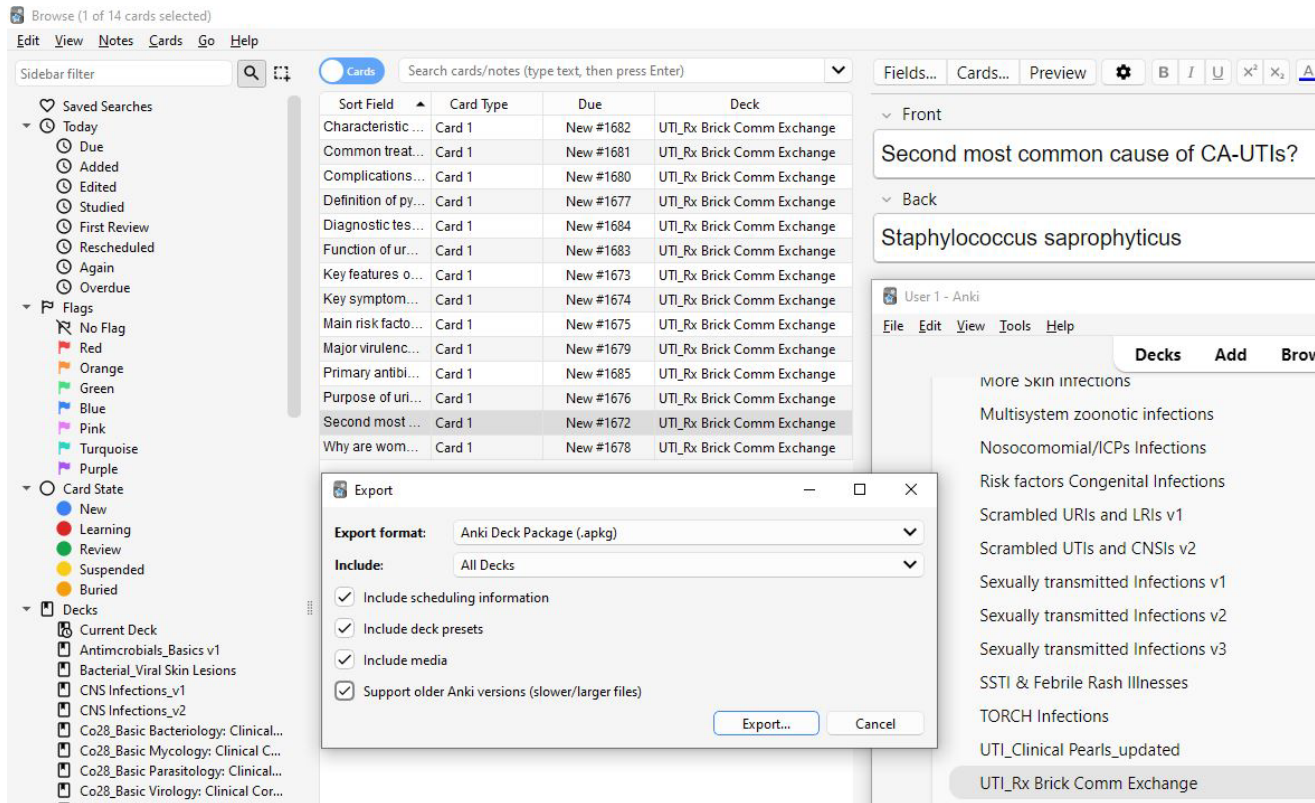
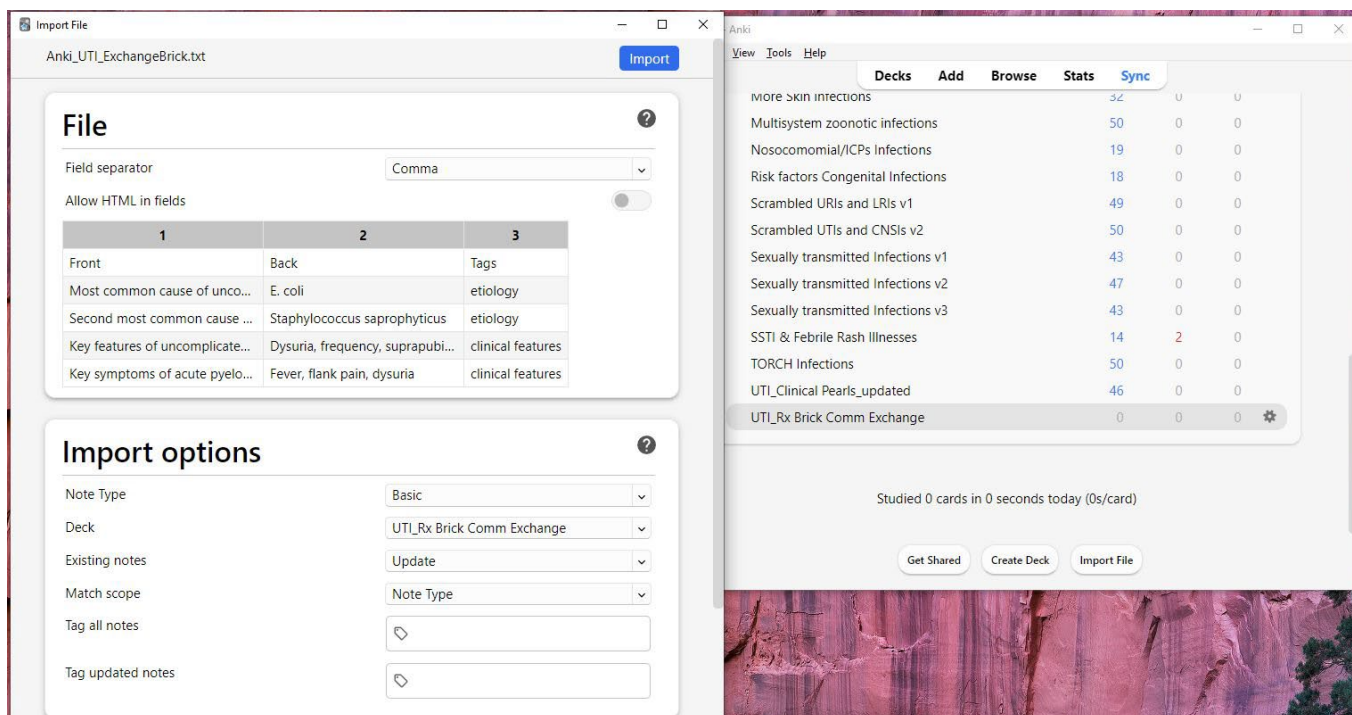
Let me know if you'd like more cards or adjustments!



5. Integration with ANKI

Usability: The process of integrating AI with ANKI emphasizes ease of use. ChatGPT-4 enables intuitive flashcard generation through interactive prompts, while exporting into ANKI's `.apkg` format ensures seamless deployment. The inclusion of beta testing and user feedback ensures the system is user-friendly, requiring minimal technical expertise. Clear instructions and ongoing support make it an efficient and practical solution for enhancing medical education.

- Import ".txt" file in ANKI (see **Figure 3-4**)
- Browse and Export Functionality: ".apkg" format (see **Figure 3-5**)



6. Testing and Feedback

- Beta Testing: User feedback from students SIG (**Figure 3-6**)

Key Feedback:

Student 1: Grateful for the resources, especially the ANKI decks, which have been invaluable throughout the year. Appreciates the dedication to helping students succeed.

Student 2: Valued the integration of multiple microbes into single cards, which aids in developing differential diagnoses. Suggested adding relevant imaging, like CXRs, to the cards.

Student 3: Finds ANKI helpful for learning microbiology. Emphasized the importance of balancing content on each card to avoid overwhelming students or leading to superficial memorization.

Student 4: Appreciates the organization of cards into sections, which aids in understanding. Suggested formatting changes, such as using bold or colored text, and varying the card format to reduce monotony.

Student 5: Found the cards useful for covering material not discussed in class, aiding in Step 1 preparation. Recommended refining the formatting for better readability.

Student 6: Praised the cards for helping with memorizing key details. Suggested correlating microbiology details with related pathologies for deeper understanding.

Student 7: Found the cards' focus on key details like oxidase positivity helpful. Suggested including more of these details and integrating treatment information into the decks.

4. Recognizing Limitations

While student feedback highlights the strengths of using ChatGPT-4 with ANKI flashcards, some limitations were noted, such as the need for more visuals, better formatting, and improved linkage of content to consolidated high-yield contexts. Addressing these will enhance the overall user experience and effectiveness of the tool.

Shared links to emulate the application:

- Chatbot (Chat GPT-4): <https://chatgpt.com/g/g-p6nRwsQ6v-anki-card-pro>
- Input (Open Exchange) Data: <https://exchange.scholarrx.com/brick/jk69xjom5ewz>
- Prompts and Outputs (Chat GPT-4): <https://chatgpt.com/share/6776cccf-d844-800c-abad-e821764ca1be>

Relevance:

AI's integration into medical education is reshaping learning by addressing the challenges of vast curricula and diverse learner needs. Tools like ANKI, combined with ChatGPT-4, streamline flashcard creation, enabling students to master complex medical topics efficiently. This alignment between AI and proven educational tools ensures deeper retention of critical knowledge. By automating processes that traditionally consumed significant time, AI fosters a focus on understanding over rote memorization, making it a vital asset for modern medical education.

Innovation:

The unique approach of integrating ChatGPT-4 with ANKI transforms traditional flashcard creation. By automating content generation and tailoring flashcards to learner needs, this methodology adapts seamlessly across disciplines. Features like image occlusion and spaced repetition further innovate the learning process, making complex subjects accessible and engaging. Such adaptability positions this approach as a template for institutions aiming to integrate AI into education.

Accessibility:

This AI-driven method is designed to cater to learners and institutions irrespective of their technological expertise. With clear workflows, students and educators can create ANKI-compatible decks from diverse materials, such as lecture notes or board reviews. The reliance on widely available tools ensures scalability, making this innovation accessible to under-resourced institutions seeking to optimize their educational offerings.

The fusion of ANKI and ChatGPT-4 enhances education by personalizing learning experiences. Medical students benefit from customized flashcards that align with individual study patterns, improving retention and exam performance. Institutions benefit from streamlined resource creation, ensuring consistent, high-quality educational content that supports student success in critical exams like USMLE Step 1.

Conclusion:

The integration of ChatGPT-4 with ANKI marks a significant advancement in preclinical medical education. This combination provides personalized, efficient, and expert-driven study aids that

cater to diverse learning styles. By delivering timely and tailored resources, this AI-driven approach enhances students' understanding of complex medical concepts, leading to a richer and more effective educational experience.

The accuracy of AI-generated content remains paramount. Feedback from seven students (and others during Saturday Board Review School at the TCU BSOM), verbal communication) on the ANKI flashcards for microbiology topics reveals a high level of satisfaction, alongside valuable suggestions for improvement. Key themes from the feedback include the addition of visuals, refinement of formatting, and better linkage of details to broader clinical contexts.

Implementing these enhancements will further optimize the learning experience and better meet the needs of medical students.

References:

1. Reichardt, N. (n.d.). AnkiGPT - Turn lecture slides into flashcards using ChatGPT / GPT and export them to Anki. Retrieved from <https://github.com/nilsreichardt/ankigpt>
2. FutureDoctor. (n.d.). Creating Effective Anki Flashcards. Retrieved from <https://futuredoctor.ai/anki/>

Section 4: Gamification in Medical Education: A Comprehensive Approach

Purpose:

We demonstrate how leveraging Chat GPT-4o and integrating serious games into curricula can foster engagement, knowledge retention, and application in challenging subjects such as clinical microbiology and immunology. This model leverages game design principles, spaced repetition, and essential elements of gameplay to create an immersive learning experience that aligns with board examination preparation while supporting diverse learning needs. By providing insights into design, implementation, and impact assessment, this work serves as a replicable framework for medical educators striving to revolutionize student engagement and performance through gamification.

Introduction

Innovation in medical education is vital for addressing complex learning challenges. At the Burnett School of Medicine at TCU, we have embraced gamification to transform clinical microbiology and immunology education. By integrating advanced educational tools with game design principles, this approach fosters an engaging and effective learning environment that prepares undergraduate medical students for real-world scenarios.

Gamification, the application of game-design elements in non-game contexts, enhances student engagement and understanding, particularly in complex subjects like microbiology and immunology. Serious games provide immersive, interactive platforms that make challenging material more approachable and memorable. Techniques such as spaced repetition ensure learners are consistently challenged at the right level, promoting mastery of critical concepts.

Leveraging AI tools like ChatGPT-4, we have further enriched this gamified approach, aligning with modern pedagogical principles. By transforming passive learning into interactive experiences, this innovation improves student engagement, retention, and application of knowledge. It equips learners with the tools needed to excel in their studies and adapt to the demands of modern healthcare.

The Kaizen Microbiology Gold Cup Game

The flagship project of our gamification efforts, the Kaizen Microbiology Gold Cup Game illustrates the power of gamified learning. This innovative tool combines spaced repetition, board-style questions, and collaborative gameplay to offer an immersive learning experience. Players embark on a quest featuring more than 625 carefully crafted questions, leveraging GPT-4o Chatbot, “AI-Tutor” (described in Section 1 of the toolkits). The robust schedule of questions cover various systems, infections, and inflammation of organ systems, integrated with clinical microbiology, immunology, and anti-infective pharmacology. Each question, a gem in its own right, is sourced from "First Aid USMLE S1" and clinical pearls and enhanced with narrative teaching elements and contemporary content.

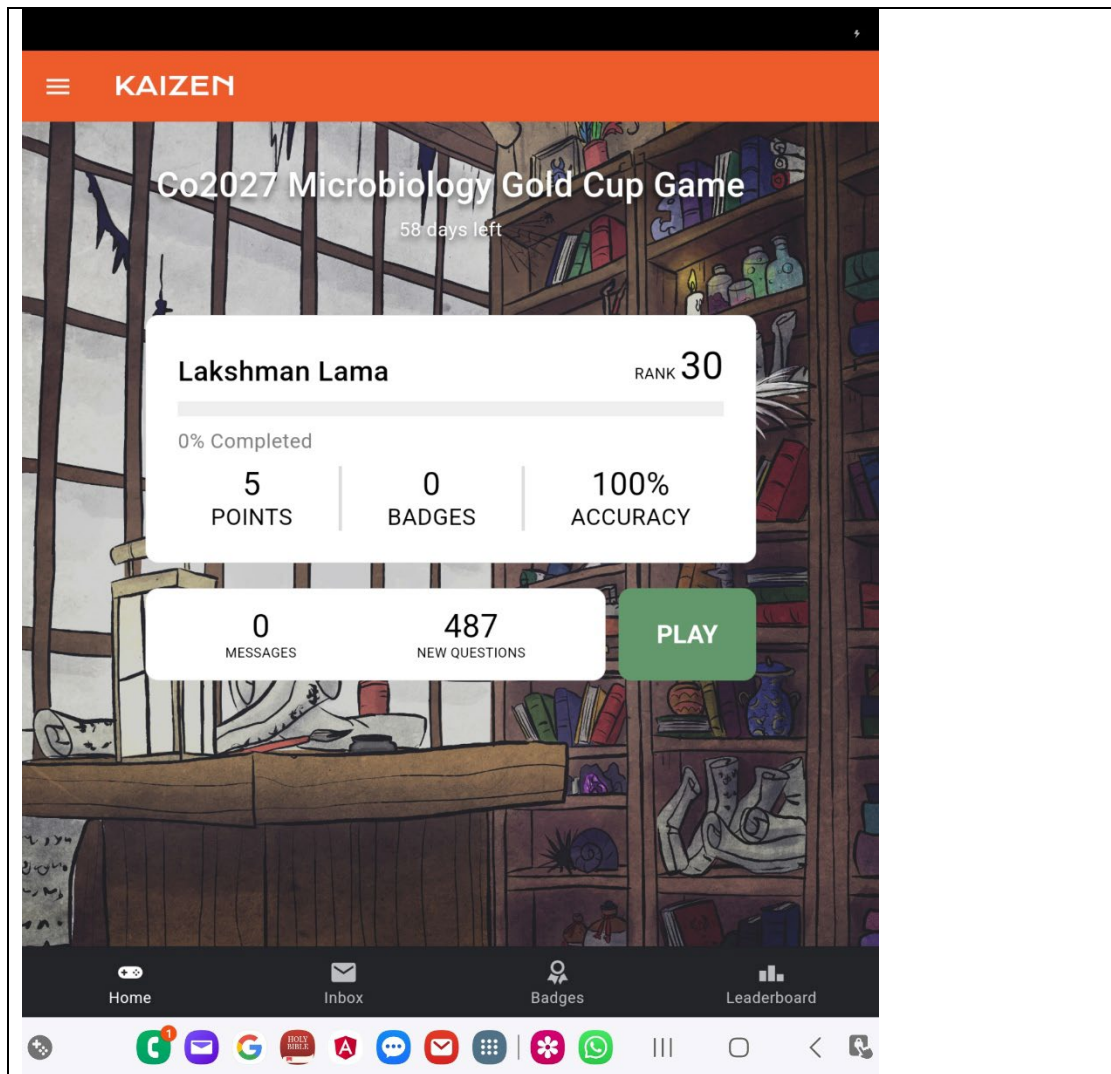
The Kaizen Game is more than just an exhilarating journey; it's a tool designed to refine understanding and application of key medical concepts. It's envisioned as an essential component of a medical student's learning toolkit, shaping their journey in the medical field.

Students are invited to embark on this adventure by contacting Professor (the author). Upon request, a link to the game is promptly provided, offering immediate access to this innovative learning experience.

This game not only provides a dynamic and engaging way to study but also serves as a preparation tool for board exams. It offers privacy controls, progress tracking, and the opportunity to tackle high-yield board-style questions. Players can enjoy the game solo or team up for a collaborative and enjoyable learning experience.

Microbiology Gold Cup Game (Co28)	Ready to play
Introducing the Microbiology and Immunology Expedition. I am thrilled to invite you on an expedition into the realms of Microbiology and Immunology through our specially designed gamified platform - (Kaizen) Microbiology Gold Cup Game! This platform fuses the power of spaced repetition with the thrill of gameplay to elevate your learning experience. What's in Store? Embark on a quest featuring 625 meticulously curated questions, traversing through the systems you've studied, and journeying into the infections/inflammation of organ systems, integrated with clinical microbiology, immunology, and anti-infective pharmacology. Each question is a gem, sourced from "First Aid" facts and enriched with the author's narrative, teaching elements, and contemporary content. Why Embark on this Adventure? The Kaizen Game is not just an exhilarating quest, but a crucible that refines your understanding and application of key concepts, sharpening your skills for a lifetime. I envision it as an essential tool in your arsenal as you carve your path in the medical field. Ready to Play? Just drop me an email at swapan.nath@tcu.edu, and your boarding pass (link) to the game will be in your hands in no time. Thank you for being the wind in the sails of educational innovation, and for raising the bar for those around you. I eagerly await celebrating your future victories and witnessing your evolution as a student physician. Your game has launched and will start on 01/07/2024. Fair winds and following seas in your academic journey, Dr. Nath	
📌 Anti-infective Agents, Body Sentinels, Cardiovascular, Central Nervous System, Gastrointestinal, Immunology, Integumentary, Medical Education, Microbiology, Musculoskeletal, Pathophysiology, Pharmacology, Renal, Reproductive, Upper/Lower Respiratory	

Invitation to register and play the game: “Microbiology Gold Cup Game (Co28)”



Game Page from a similar game, played by Co27

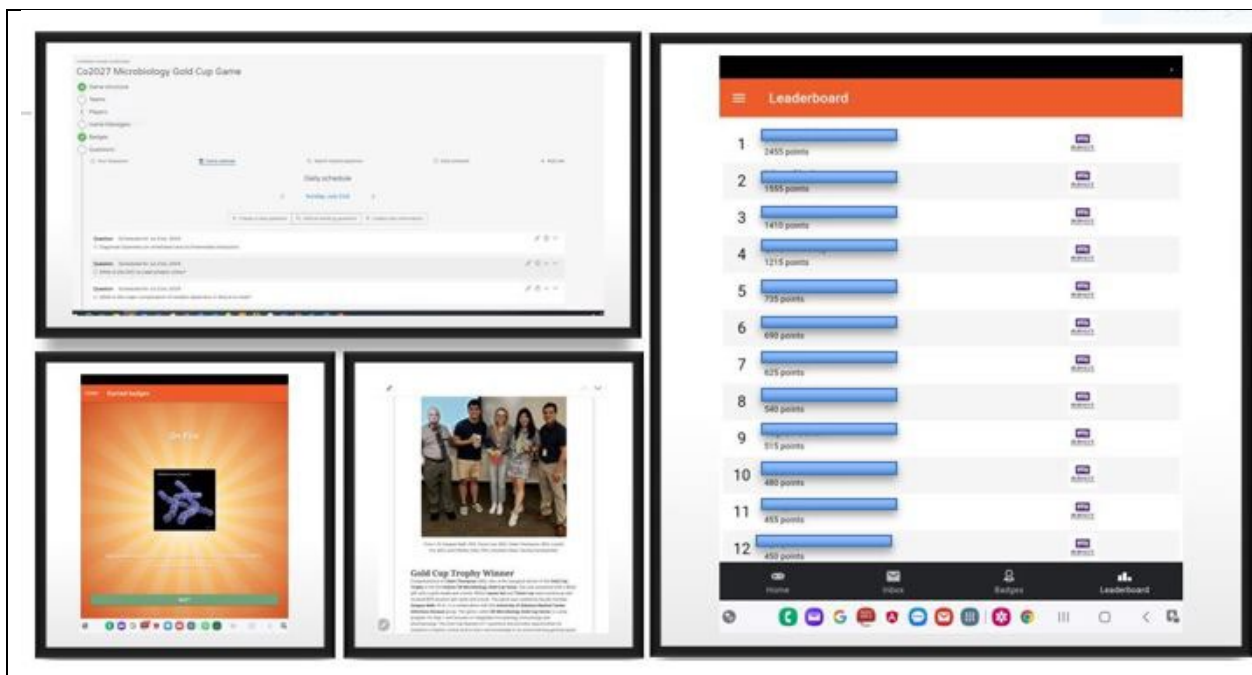
Key Features and Benefits:

1. **Integration with USMLE-Rx:** The game incorporates contents from the ScholarRx Community Exchange and USMLE-Rx as foundational content, ensuring that the learning experience is aligned with our curriculum and high-yield board exam material.
2. **Tailored Learning Experience:** The game's design facilitates spaced repetition and includes features for anonymous participation, promoting a non-competitive and stress-free learning environment.
3. **Board Exam Preparation:** The inclusion of S1 Board-style questions and detailed explanations linked to First Aid resources ensures that students are well-prepared for their exams.

4. **Collaborative and Flexible Learning:** Students can play individually or in teams, allowing for both self-paced study and collaborative learning experiences.
5. **Dynamic Engagement:** Encourages self-paced study through game mechanics, fostering critical thinking and problem-solving skills.

Implementation and Troubleshooting

To ensure the success of serious games in education, usability, cognitive load, and educational impact must be prioritized. We implemented a robust microbiology and Immunology question bank created with GPT-4 and then enriched with game elements (see below) and clinical pearls.



Game elements: Practice Questions, Leaderboard, Badges, Prizes,

Enhancing PBL with Serious Games

Serious games integrated into PBL scenarios can simulate real-life medical cases, allowing students to delve deeper into problem-solving and critical thinking. These games provide a dynamic platform for students to apply their theoretical knowledge in practical, simulated environments, enhancing their learning experience and retention of information.

Shared links:

- Chatbot (Chat GPT-4): <https://chatgpt.com/g/g-waT9NM9hZ-microtutor-ai>
- Input (faculty-authored, ScholarRx Community Exchange) Data: <https://exchange.scholarrx.com/brick/vprnj8vr9m6g>
- Iterative Prompts and Outputs of MCQs: <https://chat.openai.com/share/2271eefc-edaa-4452-a3cc-63f8efb89aa0>

Educational Impact:

By embedding game elements—like leaderboards, badges, and quizzes—into the curriculum, we have made learning more interactive and enjoyable. The game leverages spaced repetition, which is a proven method for enhancing long-term retention, and integrates transdisciplinary cognitive exercises, bringing together various disciplines such as pathophysiology and pharmacology.

The data we've gathered is promising. With 85% of students participating and 51% completing all game-related activities, the engagement levels are high. Students report that the game has significantly helped them in areas such as exam preparation, concept prioritization, and identifying knowledge gaps. Furthermore, we've observed a positive correlation between game performance and personal satisfaction with discipline-specific learning experience, indicating that serious games can indeed deepen students' understanding of complex medical concepts.

The preliminary feedback from our students has been overwhelmingly positive, with high satisfaction scores and reported improvements in understanding and retention. The gamified approach has also shown potential in fostering a deeper grasp of complex microbiological and immunological concepts.

Innovation:

At the Burnett School of Medicine, we've embraced this concept wholeheartedly. Our focus has been on integrating advanced educational tools like ScholarRx and USMLE-Rx into our curriculum, particularly in the realms of clinical microbiology and immunology. Our flagship gamification project, the Kaizen Microbiology Gold Cup Game, melds the proven benefits of spaced repetition with the excitement of gameplay, offering an immersive learning journey.

This model offers a blueprint for other institutions, demonstrating how gamified learning can merge foundational curriculum with cutting-edge tools to address diverse educational needs effectively.

Accessibility:

The gamified learning model is designed to be inclusive, catering to diverse institutions and learners regardless of their expertise with AI or gaming. User-friendly platforms like ScholarRx and Kaizen facilitate seamless implementation, ensuring learners can engage without steep technical barriers. Furthermore, options for individual and team participation create a flexible and supportive environment, empowering students across varying levels of proficiency and resources.

Usability:

Games must feature intuitive design, clear navigation, and user-friendly interfaces to encourage consistent engagement. With intuitive design and minimal setup requirements, the Kaizen Microbiology Gold Cup Game is easy to adopt. The tools and games chosen should be intuitive and user-friendly, minimizing the learning curve for students and educators alike. A well-designed interface not only makes the technology more accessible but also encourages consistent use, which is essential for effective learning. Usability encompasses ease of navigation, clarity of instructions, and a straightforward process to access learning materials and games.

Challenges in Implementation

However, the journey hasn't been without its challenges, as stated below:

- Resource-intensive development and maintenance.
- Varying levels of student engagement and adaptation to gamified environments.
- Potential misuse, leading to superficial learning rather than deep understanding.

One of the key issues is the resource-intensive nature of creating and maintaining these gamified learning tools. Developing a robust and comprehensive question bank that aligns with the curriculum and board exam requirements, for example, required significant time and effort. Additionally, the absence of a control group in our studies means that while we can observe

correlations, establishing causality between game use and improved academic performance is more challenging.

Another challenge lies in ensuring that all students benefit equally from serious games. While many students thrive in competitive, gamified environments, others may feel overwhelmed or disengaged. There's also the risk that some students might prioritize winning or earning rewards over genuinely understanding the material, which could undermine the educational goals of the gamified approach.

While our initial feedback from the Microbiology Gold Cup Game has been overwhelmingly positive, it's important to acknowledge the limitations of our study design and the resource challenges we faced. These are crucial points for discussion within the medical education community as we strive to optimize the use of serious games in our curricula.

Faculty Development: Integrating Serious Games into Teaching

In this context, faculty development programs must focus on enhancing educators' skills in various domains.

Firstly, understanding the educational potential of serious games and their alignment with course content is crucial.

Secondly, developing the technical know-how to implement these games effectively in an e-learning setting is essential.

Lastly, educators should be adept at using these games not just as a novelty but as a strategic tool that enhances the learning experience, encourages student engagement, and achieves specific educational outcomes.

Looking Ahead:

Our vision is to continuously refine and expand this gamification model. We aim to include a broader range of topics and incorporate more advanced technology, making it an integral part of medical education at TCU and beyond.

To maximize the impact of gamification, collaboration among educators is essential. Sharing resources, feedback, and best practices can refine the design and implementation of serious games, ensuring their adaptability and effectiveness across diverse educational contexts.

We advocate for the adoption of innovative instructional tools, such as gamification, to sustain and enhance learner engagement in the study of integrated microbiology, immunology, and anti-infective pharmacology. By embracing a transdisciplinary approach to foundational and system-based infectious diseases, we can provide a comprehensive and captivating educational experience for medical students.

As we continue to explore the possibilities of serious games, let's keep the conversation going. Whether it's sharing personal stories of success, debating the merits of different approaches, or discussing the challenges we've encountered, our collective insights will help shape the future of medical education.

Conclusion

The gamification of medical education represents a transformative leap forward. Tools like the Kaizen Microbiology Gold Cup Game illustrate the potential of serious games to enhance learning, foster critical skills, and prepare students for the complexities of modern healthcare. While challenges exist, a strategic approach to design, implementation, and faculty development can unlock the full potential of gamification. By fostering global collaboration, we can continue to innovate and inspire the next generation of medical professionals, ensuring that education remains dynamic, inclusive, and impactful.

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This disclosure is made in adherence to ethical guidelines and transparency requirements, emphasizing the responsible use of AI technologies in educational material development.