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# *MedMicroMaps:* An Immersive Experience for Infectious Diseases and Medical Microbiology Diagnostics

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**Abstract.** A comprehensive interactive mindmap of infectious diseases was created for pre-clinical medical students, using principles of Method of Loci and spatial recall to provide a guide with options to approach differentials from clinical, epidemiological and biological organization algorithms. Striving for diversity learning platforms, the MedMicroMaps system was initially developed in 2-D PowerPoint platform with interactive hyperlinks (pilot) and converted to Oculus Quest 3 Mixed Reality application (ongoing).

**Keywords:** Extended Reality, Mind map, Biomedical Education, Microbiology, Infectious Diseases.

## 1 Introduction

### 1.1 Rationale

Medical education has undergone major changes in the past 20 years to adapt to the digital-centered student population by modifying content for less didactic lectures and more time for self-study with e-Learning [1-2]. Many medical universities have evolved novel strategies with the curriculum to incorporate *e*-Learning material post-pandemic. Studies across diverse disciplines have established the benefits of *e*-Learning modules including virtual reality platforms [3]; however, the field of microbiology is lacking *e*-resources tailored for post-graduate studies. When the material is organized and presented from the biological classification perspective, students struggle with differential diagnoses of diverse microbes when advancing in clinical studies. Conversely, teaching with a systems-based approach yields the challenge of failing to encompass paradigm patterns of classifications of microbes. Ranges of learning preferences of diverse student populations necessitate development of *e*-learning modalities that can allow flexibility of student-led inquiry. The MedMicroMaps system was developed to adapt to virtual teaching modalities in Fall 2020 to engage global learners in Year 2 medical school during the Respiratory Infections module.

### 1.2 MedMicroMaps 2-D Pilot Study

**Study Design (PowerPoint and Webpage interface):** Students in Term 4 Spring 2022 (*n*=865) at USA-accredited medical in Caribbean in hybrid delivery format were provided link to Microbiology Digital Media Resources website hosted on SGU Digication webserver, via QR code announcement during first live lecture of infectious disease system module. A link to Feedback Survey in Qualtrics with IRB-approval was provided to students enrolled in Term 5 via Course email announcement on SGU Sakai server.

**Pilot Results:** Engagement on the SGU Digication website indicated 1000+ views per module per month for Terms 4 and Terms 5 (current total views 16K at time of writing), with increased viewing the weekend prior to the module. After the final infectious disease module, 79 students (9.1% response rate) completed the Qualtrics

survey. The majority of the responses indicated Extremely Satisfied (65%, *n*=52) or Somewhat Satisfied (21.25%, *n*=17) to "Rate your overall satisfaction with the Microbiology digital study resources".

# 2 MedMicroMaps Immersive Technology Adaptation

## 2.1 Overview of MedMicroMaps 3-D Conversion to Immersive Technologies

Medical students consistently struggle with conceptually mastering abstract concepts including microscopic infectious agents and connecting the biological characteristics to human disease or global epidemiology. Immersive technologies provide the advantage for the user to scale up to view a whole country on the globe to the size of a virus within the cell. With MedMicroMaps, the user in Oculus Quest 3 initially encounters the landing space with 4 room options: Room 1: World Globe (Where??, 1 Kilometer scale), Room 2: Clinic (Who??, 1 meter Scale), Room 3 Microbe Map (What??, 1 micrometer scale), and Room 4: Treatment (Why??, 1 nanometer scale), with a metric size slider at the bottom of the viewpoint in all rooms. The user can opt for "Explore" with all microbial selections on the Compass are options or "Case Study" with the user guided through the rooms to narrow down the microbial selections to determine the causative agent, indicated by limited sections of Compass highlighted. The "Case Study" option can be randomly populated via artificial intelligence AI or generated with input of a word document with Board-Style clinical vignette-based MCQs Multiple-Choice. The initial prototype will follow a case study of rapid onset pharyngitis caused by *Streptococcus pyogenes* in an 10-year old male of mixed-race heritage with no-underlying health conditions in mid-West USA. The application will provide a multi-user learning space for a teacher to provide instruction to students and for students to investigate the biological sciences with their peers.

## 2.2 MedMicroMaps Virtual Reality Room Interactions

Room 1: Geography and epidemiological patterns are frequently an essential clue to provide clinicians with diagnostic clues. The viewpoint will be on scale of kilometers so the user can see global patterns of infectious agents, especially critical with fungal and tropical diseases of neglect. With the Explore option, the user can select a microbe from the Compass icon and the highly endemic regions will light up (example World Health Organization maps of Malaria). With the Case Study option, the specific location of infection will light up. If a microbe such as *Strep pyogenes* is universally present, then the location of the user will indicate location of infection for both Explore or Case Study settings. The interactions in Room 1 will determine the Where of the infectious disease.

Room 2: The user viewpoint is focused on the perspective of a physician in a clinic during a patient examination. The characteristics of the patients will be divided into patient demographics and history (social, occupational, and medical) and with investigations (vital signs, physical examinations, imaging, and laboratory studies). The interface is in development with the goal of incorporating an AI-assistant to create a verbal dialogue with the user, akin to an interaction with a triage nurse with the goal of generative AI technology to create customized patients with diverse representations. Throughout the interactions and discovery of diagnostic clues, the options for causative agents will be reduced as indicated by highlighting on the Compass of corresponding microbes. With the sample Case Study, acute onset cellulitis is caused by viral or bacterial agents, but not eukaryotic pathogens.

Room 3: The Microbe Room provides the user an opportunity to view the comprehensive map, arranged by phylogenetic and biochemical relationships consistent with the Compass and 2-D version patterns and to investigate more details of a specific microbe. For Explore option, all microbes can be selected, enlarged and have an associated "folder" for the user to populate with multimedia elements (lecture PPTs/PDFs, notes, jpgs, websites, drawings, etc) as a framework for learning. For the Case Study option, only the microbes that correspond as possible causative agents to the patient in Room 2 can be selected. The user can select for the Microbiology Lab Studies to then select the correct causative agent and open the folder to find out more characteristics including virulence factors and potential treatments.

Room 4: The Treatment Room places the user within the body of patient with an infection, with the perspective of the microbes 10-100x size of user. The gaming element will be included to provide the options of an arsenal to represent choices for antimicrobials (anti-viral, -bacterial, -fungal, -parastic as weapons, specific drugs as ammunition). For the Case Study option example, the user must choose antibiotic "gun" and vancomycin as bullet to successfully kill the microbe. An incorrect choice of weapon or bullet results (ex. Penicillin for Strep throat) in overgrowth of the microbe. These visual representations will provide a fun way for students to learn pharmacology and the importance of microbial drug resistance.

## 2.3 MedMicroMaps Future Studies

MedMicroMaps will be incorporated in the curriculum design of Microbiology, Immunology and Infectious Disease course at Montana College of Osteopathic Medicine in Fall 2024. An educational research project approved by RVU-Internal Review Board is evaluating short and long term recall impacts of the MedMicroMaps system. Authors of the abstract and acknowledged contributors are developing the technology and pursuing grant opportunities from National Science Foundation, American Association for Colleges of Osteopathic Medicine and International Association for Medical Science Educators.

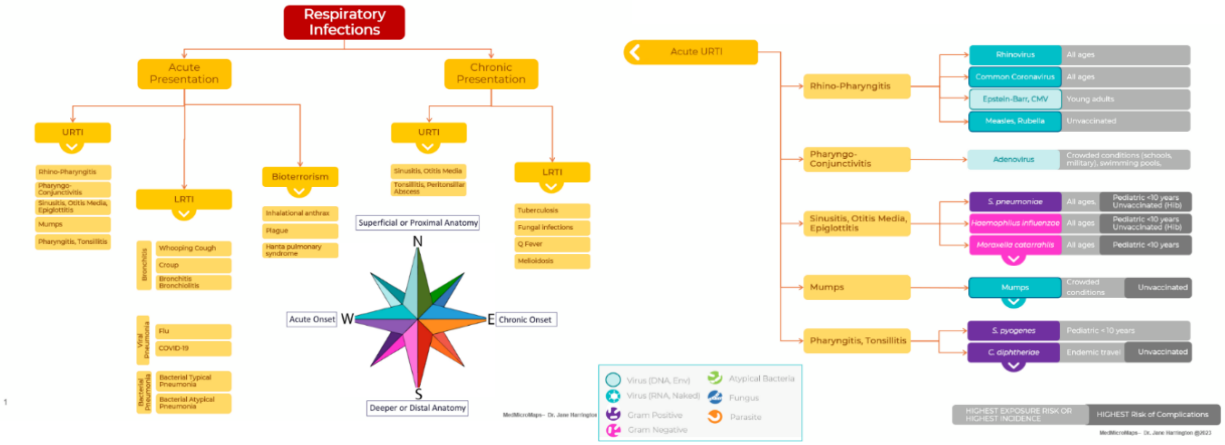


**Fig. 1.** Sample MedMicroMaps from PPT version: North-South directions correspond to anatomical location of clinical presentations (ex. Upper vs lower respiratory infections) and the West-East directions correspond to onset (Acute 24-48 hour vs Chronic 3-4 weeks). The microbial classifications are positioned based on size (smallest in NW corner, largest in SW corner) with consistent color-coding and ranking of epidemiological factors based on incidence of infections.

**Fig. 2.** Simulated Clinical Scenario of Room 2 – Clinic. The generative open source artificial intelligence program Pixverse.ai was used to create hypothetical physician scenario of child with Strep throat.

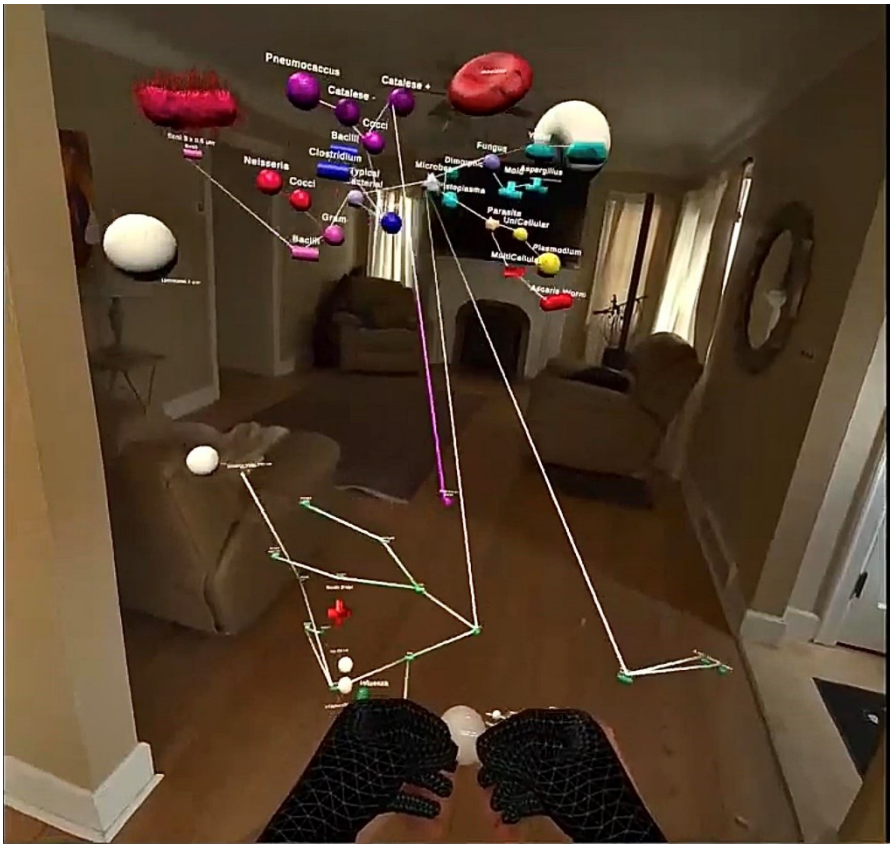


**Fig. 3.** MedMicroMaps in Augmented Immersive Platform. Representations of microbes in Room 3 – Microbe World were designed in Blender and Unity with interactive and scalable options to allow the user to compare phylogenetic and biochemical patterns or select specific microbes to explore detail.

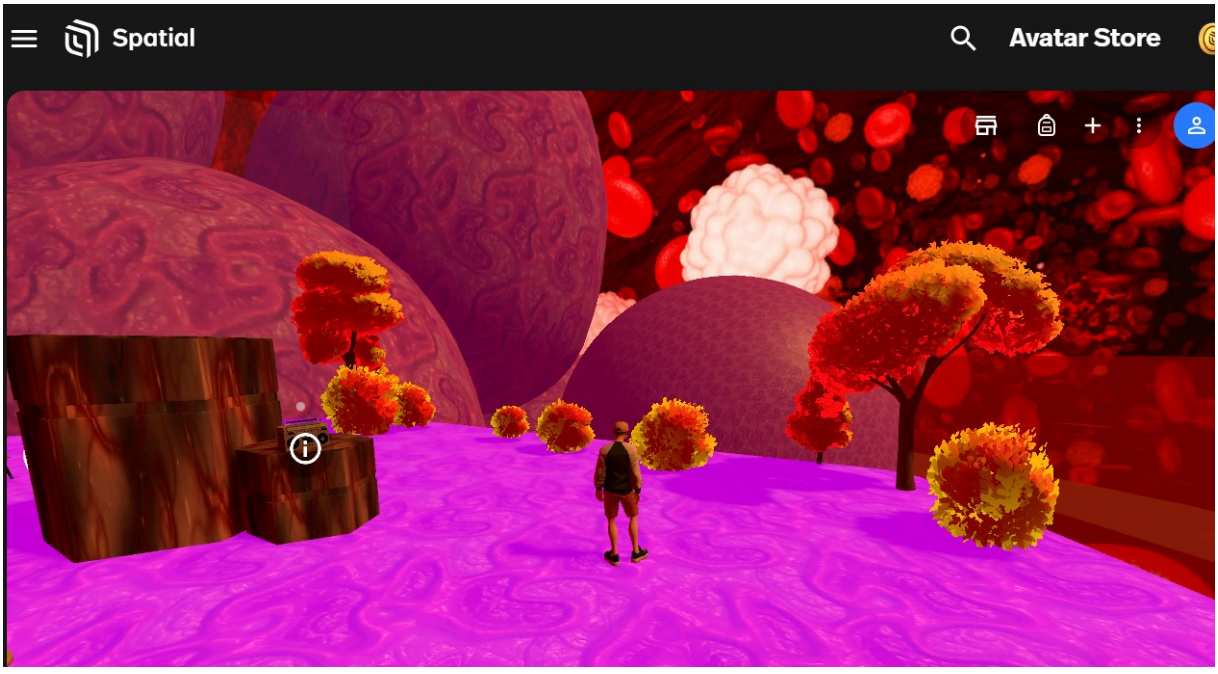


**Fig. 4.** MedMicroMaps in Virtual Immersive Platform. A demonstration of Room 4 – Treatment (B) was created in Spatial.io to represent the user perspective of the epithelial lining of the pharynx with Gram positive cocci Strep pyogenes infecting the host surface.

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