


**Review Article**

## Envisioning the Future: The Role of Large Language Models in Radiology Education

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### Abstract

The advent of Large Language Models (LLMs) like Generative Pre-trained Transformer 4 (GPT-4) (OpenAI, San Francisco, USA) has ushered in a new range of possibilities in the field of medical education. This article explores the potential of LLMs in radiology education, highlighted by examples generated by GPT-4 and GPT-4o. We demonstrate the models' application in creating interactive learning modules, personalized education, and enhancing research capabilities. Through a detailed examination of current challenges in radiology education and the unique advantages offered by models like GPT-4, this article outlines a future where technology and education converge to assist in producing more competent, knowledgeable, and adaptable radiology professionals.

**Keywords:** Large Language Models (LLMs); Radiology Education; Artificial Intelligence in Medicine; Interactive Learning Modules; Personalized Education; Natural Language Processing (NLP).

### Introduction

Radiology as a specialty has seen an exponential growth in the last few decades. This is due to multitude of factors including a steep rise in the volumes of cases, a much wider spectrum of imaging, and increasing complexity. This has resulted in overburdened radiology departments and radiologists globally. The situation is further compounded by an increase in non-interpretative work undertaken by radiologists [1].

These trends in workload patterns that led to increasing levels of burnout among radiologists and radiology educators have had an adverse impact on radiology education [2]. Radiology being a specialty that has been at the forefront of innovation, several novel methods have been tried to improve the shortcomings in radiology education.

There has been a rapid shift towards online education over the last few years, mainly fuelled by the COVID-19 pandemic. Online lectures, webinars and video-conferencing platforms not only supplemented but in many cases replaced conventional teaching [3].

Radiology Education augmented by AI has been envisioned to provide a more precise and personalised education to trainees based on their interests, strengths and weaknesses. Both NLP tools and computer vision algorithms are considered to be useful in this context [4].

LLMs like GPT-4 and GPT-4o, with their advanced natural language processing and machine learning capabilities, present an opportunity to revolutionize radiology education, making it more accessible, interactive, and personalized.

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## The Current Landscape of Radiology Education

Radiology education relies heavily on the acquisition of theoretical knowledge, practical skills, and the ability to apply this knowledge in clinical settings. However, the exponential growth in medical knowledge, coupled with advancements in imaging technology, places a significant learning burden on students and professionals. Additionally, the heterogeneity in learner pace and style necessitates a more customized approach to education.

The conventional methods of teaching were hampered substantially by limitations like availability of case materials and experienced educators. This is particularly true in developing countries with heterogenous training curricula and scarce resources. The COVID-19 pandemic has revolutionised radiology education by catalysing rapid progress in various forms of online education methodologies [5].

Artificial Intelligence (AI) and Machine Learning technology heralded a new chapter in the evolution of radiology. AI products that have been approved by the FDA include applications throughout radiology workflow [6]. The advent of LLMs has further transformed this space with a large range of additional capabilities, including enhancement and personalisation of radiology education.

## Potential to transform radiology Education with LLMs

### Interactive Learning Modules

LLMs can generate dynamic, case-based learning scenarios that mimic real-life radiological cases, offering students a hands-on learning experience. These modules can adapt to the learner's responses, providing instant feedback and tailored learning paths.

Figure 1 below is an example of an instant interactive learning module generated by GPT-4 for a 3rd year radiology resident on Acute Cholecystitis

#### Example 1:

**Prompt:** I am a 3rd year Radiology resident. Generate an interactive learning module for me on Acute Cholecystitis

**GPT-4 Responses:** Below are some screenshots from a comprehensive module immediately generated by GPT-4

### Personalized Education

By analysing individual learning patterns and progress, LLMs can customize educational content, focusing on areas that require improvement. This personalized approach ensures that learners at different levels receive the support they need to advance their skills.

Figure 2 is an example screenshot of further interaction with GPT-4 in relation to the conversation shown in Figure 1

**ChatGPT**  
**Interactive Learning Module: Acute Cholecystitis for Radiology Residents**

**Module Overview:**  
Welcome to the Interactive Learning Module on Acute Cholecystitis designed for 3rd year Radiology Residents. This module aims to enhance your understanding, diagnostic skills, and clinical decision-making related to Acute Cholecystitis through interactive case studies, quizzes, and real-life imaging interpretation.

**Objectives:**

1. Understand the pathophysiology and clinical presentation of Acute Cholecystitis.
2. Identify key imaging findings associated with Acute Cholecystitis on Ultrasound, CT, and HIDA scans.
3. Develop an approach to the interpretation of imaging studies in patients suspected of having Acute Cholecystitis.
4. Apply knowledge to diagnose Acute Cholecystitis accurately and suggest appropriate management.

**Module Components:**

**Section 1: Background Knowledge Quiz**

- **Quiz 1:** Pre-module quiz to assess baseline knowledge about Acute Cholecystitis.
- **Content Review:** Brief overview of Acute Cholecystitis – Pathophysiology, clinical features, and diagnostic criteria.

**Section 2: Imaging Studies in Acute Cholecystitis**

- **Interactive Guide:** Explore an interactive guide detailing imaging techniques (Ultrasound, CT, HIDA Scans) and their role in diagnosing Acute Cholecystitis.
- **Image Gallery:** A collection of anonymized, real-life images showing classic and atypical cases of Acute Cholecystitis.

**Section 3: Case Studies**

- **Case Study 1:** Standard presentation on Ultrasound – A step-by-step walkthrough of interpreting key findings with interactive annotations.
- **Case Study 2:** Atypical presentation on CT – An interactive case requiring you to identify subtle signs of Acute Cholecystitis.
- **Case Study 3:** HIDA Scan interpretation – Evaluate scan results to confirm or rule out Acute Cholecystitis, with instant feedback.

**Section 4: Diagnosis and Management**

**Figure 1:** an example of an instant interactive learning module generated by GPT-4 for a 3rd year radiology resident on Acute Cholecystitis

**Question 1: What is the most common cause of Acute Cholecystitis?**

A) Cholelithiasis  
B) Alcohol consumption  
C) High-fat diet  
D) Viral infection

**Question 2: Which imaging modality is considered the first-line for diagnosing Acute Cholecystitis?**

A) CT Scan  
B) MRI  
C) Ultrasound  
D) X-Ray

**Question 3: What is a positive Sonographic Murphy's sign?**

A) A patient experiences pain when pressure is applied with the ultrasound probe over the gallbladder.  
B) A patient does not experience pain when pressure is applied with the ultrasound probe over the liver.  
C) The presence of gallstones in the gallbladder without any inflammation.  
D) The gallbladder appears contracted on ultrasound imaging.

**ChatGPT**  
**Your Answers and Feedback:**

**Question 1: Correct!**  
The most common cause of Acute Cholecystitis is A) Cholelithiasis, or gallstones. These block the cystic duct, leading to inflammation of the gallbladder.

**Question 2: Correct!**  
C) Ultrasound is considered the first-line imaging modality for diagnosing Acute Cholecystitis due to its sensitivity in detecting gallstones and gallbladder inflammation.

**Question 3: Correct!**  
A positive Sonographic Murphy's sign (A) occurs when a patient experiences pain upon pressure with the ultrasound probe over the gallbladder. It's a hallmark sign suggesting Acute Cholecystitis.

**Question 4: Correct!**  
D) Gallbladder atrophy is NOT a typical finding of Acute Cholecystitis on ultrasound. Instead, Acute Cholecystitis is associated with gallbladder wall thickening, pericholecystic fluid, and the presence of gallstones.

**Question 5: Correct!**

**Figure 1B:** an example of an instant interactive learning module generated by GPT-4 for a 3rd year radiology resident on Acute Cholecystitis

**Next Steps in the Module:**

In the subsequent sections, you'll dive deeper into case studies, where you'll interpret actual imaging studies to diagnose Acute Cholecystitis and differentiate it from other pathologies. Plus, you'll explore management strategies and the latest guidelines for treatment.

Would you like to proceed with case studies, or explore another area of Acute Cholecystitis in more detail?

**You**  
can you give me some case studies

**ChatGPT**  
Certainly! Here are two simulated case studies designed to enhance your diagnostic skills in identifying acute cholecystitis through imaging studies. While we cannot display actual images here, I'll describe the imaging findings and ask you to interpret them based on the provided descriptions.

**Case Study 1: Standard Presentation**

**Patient History:**  
A 45-year-old female presents to the emergency department with a 6-hour history of sharp right upper quadrant pain that radiates to the back. She reports nausea but no vomiting. The pain intensifies with deep breaths.

**Figure 2:** An example screenshot of further interaction with GPT-4 in relation to the conversation shown in Figure 1

**Enhancing Research and Critical Thinking**

LLMs can assist students and professionals in exploring the latest research findings, understanding complex methodologies, and developing critical thinking skills. It can summarize research articles, generate hypotheses, and even propose experimental designs, serving as an invaluable tool for both learning and innovation.

**Simulation and Virtual Mentorship**

Through realistic simulations, LLMs provide a safe environment for learners to practice interpretative skills without the risk of patient harm. Furthermore, its ability to provide mentor-like guidance and answer questions 24/7 ensures continuous learning opportunities outside traditional settings.

**Virtual Radiology Assistants**

LLMs can power virtual assistants that can guide students through complex radiological images, offering explanations and answering questions in real-time. This could significantly enhance understanding by allowing students to interact with the assistant to clarify concepts, explore different diagnoses, and understand the rationale behind certain imaging techniques

Figure 3 below is an example of GPT-4 acting as a virtual assistant to a radiology resident while they're reviewing a complex CT scan

**Prompt 1:** I am looking at a CT scan which is showing small bowel obstruction and gall stones. Please prompt me on the various things I need to be looking for

**GPT 4 Responses:** Below are some screenshots of the responses from GPT-4

**ChatGPT**  
When evaluating a CT scan showing small bowel obstruction (SBO) and gallstones, it's crucial to conduct a thorough assessment not only to confirm these findings but also to identify possible causes, complications, and related pathologies. Here's a structured approach to guide your evaluation:

**Small Bowel Obstruction (SBO)**

- Location of Obstruction:**
  - Identify the transition point between dilated and collapsed bowel segments. This can help localize the obstruction.
  - Note any differences in bowel caliber, as this can indicate the obstruction's severity and duration.
- Cause of Obstruction:**
  - Look for any intraluminal, mural, or extrinsic causes. Intraluminal causes might include gallstone ileus; mural causes could be related to Crohn's disease, neoplasms, or infections; and extrinsic causes might involve adhesions or hernias.
  - Specifically, for gallstone ileus, look for a fistula between the gallbladder and the bowel, and the presence of ectopic gallstones within the bowel lumen.
- Bowel Wall Appearance:**
  - Assess the bowel wall for thickening, enhancement after contrast administration, or signs of ischemia such as pneumatosis intestinalis (air within the bowel wall) or portal venous gas.
  - Check for free fluid or localized fluid collections that might indicate perforation or abscess formation.
- Mesenteric Vasculature:**
  - Evaluate the mesenteric vessels for any signs of vascular compromise, such as thrombosis or embolism, which can cause ischemic bowel conditions.
- Associated Findings:**
  - Look for signs of dehydration or electrolyte imbalances, such as reduced kidney size or abnormal adrenal gland size, which can accompany severe or prolonged obstruction.

**Gallstones**

- Location:**
  - Confirm the presence of gallstones within the gallbladder or the biliary tract. Note any stones in the cystic duct, common bile duct, or within the bowel indicating gallstone ileus.
- Gallbladder Wall:**
  - Evaluate the gallbladder wall for thickening, which might suggest cholecystitis.
  - Look for pericholecystic fluid as a sign of inflammation.
- Biliary Tree:**
  - Assess the bile ducts for dilatation, which could indicate obstructive jaundice or cholangitis if an infection is present.
- Complications:**
  - Check for signs of complications related to gallstones, such as biliary pancreatitis, cholecystoenteric fistula (especially in the context of gallstone ileus), or ascending cholangitis.
- Other Abdominal Organs:**
  - Conduct a comprehensive review of other abdominal organs to rule out any related or unrelated pathologies that could influence management strategies.

After thoroughly evaluating these aspects, the next steps would include correlating your radiologic findings with the clinical presentation, considering possible differential diagnoses, and determining the appropriate management plan, which could range from surgical intervention to conservative management depending on the severity and cause of the findings.

**Figure 3:** An example of GPT-4 acting as a virtual assistant to a radiology resident while they're reviewing a complex CT scan

**Prompt 2:** There seems to be air in the biliary tract along with small bowel obstruction and gall stones. What is the most likely diagnosis

**GPT-4 Responses**

**Simulation of Patient-Radiologist Interactions**

LLMs can be employed to simulate conversations between radiologists and patients or other healthcare providers, improving communication skills critical for conveying diagnosis, discussing treatment options, and managing patient expectations.

**Language Translation and Global Education**

LLMs language capabilities can be leveraged to translate complex radiological content and educational materials into multiple languages. This democratizes radiology education, making high-quality resources accessible to non-English speaking students around the world, thus fostering a more inclusive global radiology community.

**ChatGPT**

Given the combination of air in the biliary tract (pneumobilia), small bowel obstruction (SBO), and gallstones, the most likely diagnosis is **Gallstone Ileus**.

**Gallstone Ileus** is a rare form of mechanical bowel obstruction caused by an impacted gallstone that has entered the gastrointestinal tract through a cholecystoenteric fistula, most commonly a cholecystoduodenal fistula. This condition typically occurs as a complication of chronic gallstone disease, where repeated episodes of inflammation lead to the formation of a fistula between the gallbladder and the adjacent intestine. A large gallstone passing through the fistula into the bowel can then obstruct the small intestine, commonly at the ileocecal valve due to its narrow lumen.

**Key Diagnostic Features of Gallstone Ileus Include:**

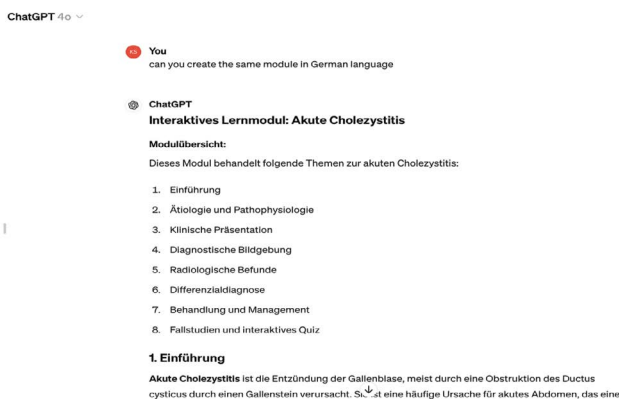
1. **Pneumobilia:** Air in the biliary tree, indicating an abnormal communication between the biliary system and the intestinal tract.
2. **Small Bowel Obstruction:** Signs of mechanical obstruction on imaging, such as dilated bowel loops with air-fluid levels.
3. **Ectopic Gallstone:** Visualization of a gallstone within the intestinal lumen, especially if it's located distally from the gallbladder.
4. **Possible Visualization of a Fistula:** While the fistula itself may not always be directly seen on imaging, indirect signs such as air in the gallbladder or the presence of gallstones outside the biliary tract can suggest its existence.

**Management and Treatment:**

- **Gallstone Ileus** is typically managed surgically, often requiring enterotomy to remove the obstructing gallstone. The decision to address the cholecystoenteric fistula during the same operation is controversial and may depend on the patient's clinical condition.
- Non-operative management may be considered in highly selected cases or in patients who are poor surgical candidates, but it is not the standard of care.

Given the complexity and potential complications associated with **Gallstone Ileus**, a multidisciplinary approach involving radiologists, surgeons, and gastroenterologists is essential for optimal management. Prompt diagnosis and intervention are crucial to prevent further complications and improve outcomes in affected patients.

Figure 4 below is a screenshot of the same module demonstrated in earlier examples, generated in German language by GPT-4o



**Augmented Reality (AR) Integration**

Combining LLMs with AR technologies can lead to development of immersive learning experiences where students can interact with 3D models of anatomy and pathology. LLMs can provide real-time, context-aware information and guidance as students navigate through different layers of anatomy or pathological findings in an AR environment

**Challenges and Considerations**

While LLMs offer numerous advantages, their integration into radiology education requires careful consideration of several factors, including ensuring accuracy of medical content, addressing ethical concerns related to data privacy, and the need for human oversight to contextualize AI-generated content.

The potential for LLMs to produce fake and potentially harmful information based on their logic (i.e., hallucinations) is a significant drawback. Patients should be made aware of this when they receive such information [7].

**Conclusion**

The integration of LLMs like GPT-4 into radiology education has the potential to significantly enhance the learning experience, offering personalized, interactive, and comprehensive educational tools. By overcoming current educational challenges and leveraging the capabilities of LLMs, the future of radiology education can be reshaped to produce more skilled, adaptable, and proficient radiologists. As we explore the potential of this technological revolution in radiology education, it is imperative to navigate the integration of LLMs with consideration for its limitations and ethical implications, ensuring that the technology serves to augment rather than replace the invaluable human elements of education and patient care.

During the preparation of this work the authors used Chat GPT-4 and GPT-4o in order to improve readability of certain portions of this article. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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