# Designing a Simulated Patient System for Medical Education

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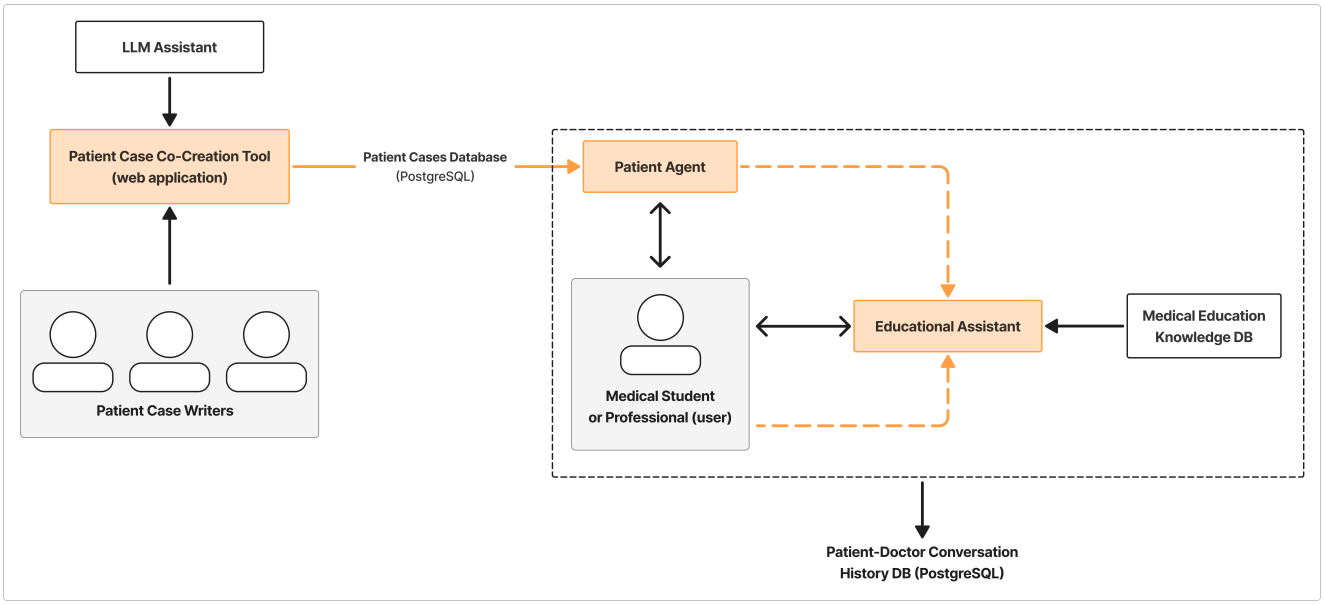


**Figure 1: Simulated Patient System Architecture**

## ABSTRACT

The foundation of successful patient-doctor relationships lies in effective communication, which promotes patient autonomy, trust, and comprehension. As a result, medical education has placed growing emphasis on improving clinical communication skills. Medical students gain experience through interactions with standardized patients (SPs) - trained individuals who simulate specific patient scenarios in controlled educational settings. However, recruiting SP actors can be difficult, and students tend to have limited interactions with them (i.e., during weekly classes or final examination).

In this work, we develop an LLM-driven simulated patient system in collaboration with an R1 research university's SP training program. The system consists of the patient agent, which simulates a SP case, alongside an educational agent, which can provide helpful suggestions and feedback to the user. We hope that this system can augment pre-existing standardized patient programs to improve clinical competency among medical students and professionals.


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## CCS CONCEPTS

• **Human-centered computing** → **User interface programming**; • **Computing methodologies** → **Natural language processing**; • **Applied computing** → **Interactive learning environments**.

## KEYWORDS

Medical Education, Standardized Patient, Clinical Communication Skills, Patient Simulation, Natural Language Processing

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## 1 INTRODUCTION

Effective communication skills are an integral part of the patient-doctor relationship, aiding in patient autonomy, trust, and comprehension [6, 19]. Thus, there is an increased effort directed towards developing clinical communication skills in medical education [8, 9]. In medical school, students practice these skills with trained human actors who recreate patient scenarios, known as standardized patients (SPs) [3]. However, student's interactions with SPs are limited

since they are hired for clinical skills classes or final examinations. SP recruitment is also difficult since one typically undergoes a long training program with limited work hours, depending on medical school's needs. Furthermore, SP profiles rarely represent patients from vulnerable populations (e.g., people with language barriers, trauma, chronic and/or mental illnesses) who are most likely to receive substandard medical care [4]. Consequently, medical students can't frequently use and develop these skills in realistic settings until their residency or as a practitioner. Thus, there is a need for medical education tools to help medical students and professionals practice their clinical conversational skills.

This research project aims to develop a large language model (LLM)-driven simulated patient system as an educational tool for medical students and professionals. We have been in conversation with an R1 research university's SP training program and will be conducting an interview study to learn about the different components of simulating patients with real actors. This will help inform the development of our system, which is outlined in Figure 1. It consists of a patient co-creation tool, which can be used by patient case writers to assist them with developing patient scenarios. The patient cases created using the tool will then be used in the simulated patient system to create patient agents. Medical students or professionals can then interact with the patient agent to simulate a patient-doctor conversation. While they interact with the patient agent, the user can also get feedback and suggestions from the educational assistant.

So far, we have developed (a) the patient agent, which simulates a patient scenario, and (b) the educational agent, which provides helpful suggestions and feedback to the user. Both components are grounded in established pedagogical principles from the collaborating university's SP training program: the patient simulations adhere to clinical case design standards, while the feedback mechanisms implement evidence-based frameworks for medical student education. This proposed system can help both medical students and practitioners learn to effectively communicate with patients from a wide range of diverse backgrounds with complex needs, filling a gap in medical education for improved clinical competency.

## 2 RELATED WORK

### 2.1 Use of AI for Medical Education

Previous work has developed conversational agents that simulate patients for medical education. Lopez et al. developed an agent that simulated a patient whose behaviour was coordinated through various control modules[14]. Recent advances in natural language processing (i.e. LLMs) have led to the development of more realistic agents [15]. In the past 5 years, many researchers have developed virtual/simulated patients via LLM prompting [2, 5, 12, 17, 20]. In fact, Yamamoto et al. found that medical students who used their LLM simulated patient intervention received significantly higher scores than the control group [20]. AI patient simulations are also being used for undergraduate nursing education [10, 11, 18]. Despite the recent proliferation of work in this field, there is still very little integration of such tools within medical education systems [1]. This may be due to the disconnect between the development of such tools and medical institutions that may need it [1].

In this work, we are directly collaborating with an R1 research university's medical school and SP training program to design, develop, and evaluate the simulated patient system. We hope that emphasizing learning from pre-existing SP training programs improves the usefulness and ease with which the system is integrated within medical school.

### 2.2 Standardized Patient Training Program

In medical school, students learn to interact with patients by interacting with actors simulating a patient scenario, known as standardized patients (SPs) [3]. SPs are an integral part of teaching communication skills to medical students by helping them put their theoretical knowledge to practice [13]. These actors go through a rigorous training program where they learn how to reproduce a patient scenario while incorporating the patient's personality traits and behavioural characteristics. We are working with an R1 research university's SP training program to gain insight into how human actors simulate scenarios to integrate into our system design.

*2.2.1 Key Stakeholders.* The SP training program is a complex organization involving multiple stakeholders who collaborate to create realistic clinical scenarios for medical education. At our collaborator university, the stakeholders include:

(1) Trainees: people who act as SPs
(2) Trainers: teachers who help the SPs learn to properly simulate a patient scenario
(3) Patient Case Writers: medical experts who create patient cases consisting of multiple pages of detailed descriptions about their history, symptoms, etc.
(4) Preceptors: medical experts who observe the interaction between student and SP and provide feedback to the student to improve their communication skills
(5) Administrators: help with recruiting actors, booking SPs for classes/exams, and scheduling

Eventually, the goal of the simulated patient system is to meet the needs of key stakeholders mentioned above - for example, decreasing case writers heavy workload with the patient co-creation tool to help them Similarly, challenges with recruiting actors from wide demographic backgrounds may be mitigated if our system can realistically represent diverse patients.

## 3 DESIGN OF THE SIMULATED PATIENT SYSTEM

The simulated patient system was designed primarily based on our collaborator university's SP case catalogue [7], which provides details on both patient scenarios and educational feedback the medical student should receive during the interaction.

The cases are developed for 6 unique foundational themes that medical students learn about:

(1) *Medical Foundations 1 (MF1)* which is an introduction to medical examinations - taking a patient history and vital signs as well as physical, respiratory, cardiac, and head & neck exams.
(2) *Medical Foundations 2 (MF2)* focuses on renal and hematology, teaching students how to take genitourinary history

and renal, lymph node, hematologic, and peripheral vascular exams.

(3) *Medical Foundations 3 (MF3)* focuses on gastrointestinal (GI), endocrinology, and reproduction. Students are taught how to take abdominal, diabetes, thyroid, adrenal, and obstetrical exams as well as newborn, adolescent, gynecological and sexual history.
(4) *Medical Foundations 4 (MF4)* focuses on musculoskeletal medicine, neuroscience, and brain & behaviour. Here, students learn about musculoskeletal exams (including joint exams), neurological exam, mental status exam, assessment of mood/anxiety, eating disorders assessment, risk assessment of psychosis/delirium, and substance use disorder assessment.
(5) *Integration Foundation (IF)* which introduces new learning objectives while reviewing concepts from prior MFs, spanning from simple to complex across multiple clinical scenarios and circumstances.
(6) *Transition to Clerkship (TTC)* which ensures students stay on track during completion of pre-clerkship and moving to early clerkship.

Each foundational theme has a set of patient cases which aim to teach students the learning objectives outlined above. The cases thoroughly outline the patient scenario, which is used for the development of the patient agent (Section 3.1.1), as well as the learning objectives and things a preceptor should look out for, which is used for building the educational assistant (Section 3.1.2).

## 3.1 System Framework

The system currently consists of two main components: (a) the *patient agent*, which simulates a patient scenario, and (b) the *educational assistant*, which can provide suggestions and feedback to the user to improve their clinical communication skills.

*3.1.1 Patient Agent.* The patient agent is the core element of the system, and it consists of a variety of components, outlined in Table 1. Some components are present every patient case (e.g., demographics, case stem, the 'Big 6') but others vary on a case-by-case basis, depending on the learning objectives and complexity of the scenario. For example, if a learning objective is to improve patient-centred communication skills, there will be an outline of the patient's perspective.

All of the components outlined in each patient scenario are used to create the patient agents via the system prompt, shown in Figure 2. The patient information is provided in bullet points in markdown format. Alongside the patient scenario description, the prompt also includes a few guidelines so that the LLM can more realistically present as a layperson patient and to promote student's learning.

*3.1.2 Educational Assistant.* The educational assistant mimics the role of a preceptor during an interaction between a student and SP. Note that the goal isn't to 'replace' the preceptor during the simulation, but rather provide students with feedback outside of classes and examinations to help students efficiently learn from their mistakes.

The educational assistant consists of (a) information provided in the case catalogue for the preceptor, (b) list of questions that

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You are a patient at a <setting> with the following information:

<patient description in Markdown>

Have a conversation with your healthcare provider, describing your symptoms based on your
personal characteristics.

Important guidelines:
- Answer all close-ended questions with only "yes" or "no".
- Ask for clarification if the clinician uses any technical terms or medical jargon.
- Answer only one question if the clinician uses a stacked or compound questioning
technique i.e. asking multiple questions in one statement.
- Do not ask the clinician any questions.
- If you are asked clinical content-type questions and the answer is not in the case,
please respond with "no", "normal", "I don't know", "I don't remember", or a neutral answer
as appropriate, we do not want to add clinical complexity.
- If you are asked a personal/lifestyle question which is not in the case, feel free to
fill in that information with an answer that is as non-contributory as possible.
- All the information in this case should only be answered if the clinician specifically
ask about it. Do not divulge any information that is not asked for, and ask for
clarification if a very general question is asked.
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**Figure 2: System prompt for the Patient Agent**

medical students learn during their communications skills class, and (c) the Kalamazoo consensus statement [16], a checklist of the seven essential elements of effective patient-doctor communication. The catalogue provides an overview of the learning objectives for each case (e.g., 'establish therapeutic relationship with patient'), the type of case it is (e.g., interviewing skills, history taking, mental status exam, etc.) and the patient diagnosis. In the communication skills class, medical students are provided with sample questions that they can ask for each patient component (including HPI, the 'Big 6', RoS, and Patient Perspective).

Additionally, the educational assistant is provided with the conversation history between the user and patient agent to ensure that it has the right context to provide suggestions or feedback, while avoiding direct references to hidden learning objectives. Instead, it provides guidance that prompts students to independently discover key aspects of the case.

## 3.2 Implementation

The system was built using Next.JS, a React-based framework for building modern web applications, and deployed on Vercel, a cloud platform that provides both hosting infrastructure and data storage. Both the patient agent and educational assistant were developed using OpenAI's GPT-4o mini, though we intend to experiment with newer models. The prompts for both agents were iterated on based on our medical student collaborator's interactions with the agents. The user chat history is stored in a PostgreSQL database through Vercel.

## 3.3 User Interface

The application has two pages, the start page (Section 3.3.1) which displays the patient stem and the main system interface (Section 3.3.2) which consists of the patient agent and the educational assistant chatbots.

*3.3.1 Start Page.* The simulation starts with a short introduction to the scenario alongside instructions to guide the user. Two such patient stems are shown in Figure 3, with varying levels of detail. With more complex scenarios, the user is provided with detailed historical context, vital signs and/or blood-work results (e.g., Nicky Ferguson in Figure 3). This is modelled after the 'patient stem'

**Table 1: Outline of the components of a standardized patient, its overview and use within the patient agent**

| Patient Component | Overview and Use within Patient Agent |
|---|---|
| Patient Demographics | Basic information about the patient including their name, age range, gender expression, and pronouns. Gender and pronouns tend to be unspecified in the case catalogue and based on the SP actor themselves. Thus, these are randomly generated for the patient agent. The patient agent's age is randomly generated based on the age range provided. |
| Case Stem | A high-level overview of the patient scenario that medical students are given at the beginning of their interaction with the SP. In the simulated patient system, this is displayed in the start page (Section 3.3.1). |
| Setting | The location where the simulated interaction occurs (e.g., emergency department, walk-in clinic, virtual family medicine clinic). |
| History of Presenting Illness (HPI) | Overview of the patient's symptoms including onset, precipitating/palliating, quality, region/radiation, severity, and timing. |
| The 'Big 6' | The 6 important factors that can impact the patient's clinical outcomes: medications, allergies, past medical, surgical, family, and social history. Social history includes patient's living arrangements, support system, education, occupation, smoking, alcohol, recreational drugs, diet and exercise. |
| Review of Systems | Pertinent information on the patients bodily systems including constitutional, dermatological, head, eyes, respiratory, and cardiovascular. |
| Patient Perspective | Details on the patient's Feelings, Ideas, Functioning, and Expectations (FIFE).This is present in cases with a focus on patient-centred care. |
| Associated Symptoms | A more thorough overview of the patient's symptoms, and is only present in cases when the previous sections do not adequately describe the symptoms. The specific fields vary based on the type of case it is. |
| Environmental and Exposure History | An outline of the patient's lifestyle and living situation including the community they reside in, details about their home, hobbies, occupation, personal habits, diet and any drug consumption. |
| Vital Signs | Includes patient's temperature, heart rate, blood pressure, respiratory rate, and O2 saturation. There may also be details on blood-work (e.g., complete blood count (CBC), liver panel) and/or physical tests (e.g., electrocardiogram (EKG), CT scans). This section is present for very complex cases, mainly within the last few of the foundational themes. |
| Mental Status Exam | An overview of the patients behaviour to help the student conduct a mental status assessment. It predominantly appears in cases from Theme MF4, which focuses on behavioural and mental health, and includes a description of their appearance, cooperation, mood, affect, speech, thought process/content, perception, cognition, and insight/judgment. |

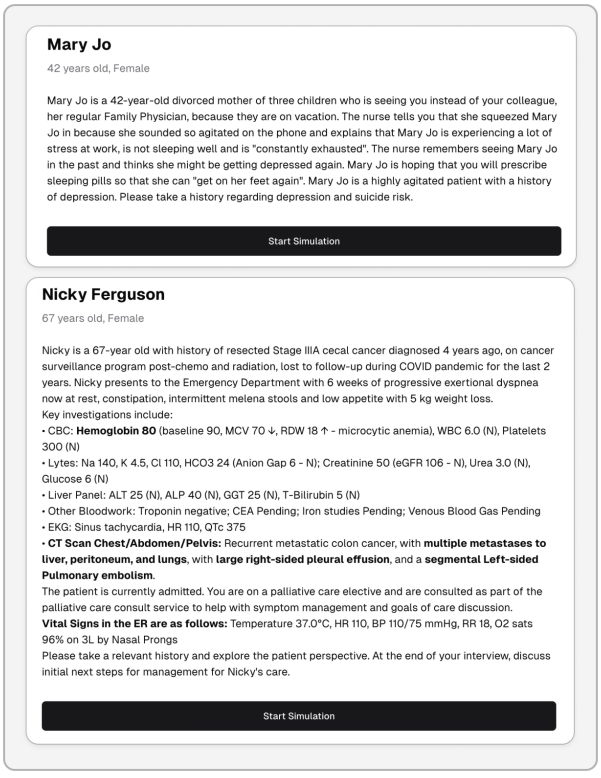


**Figure 3: The start pages for two patient agents, Mary Jo and Nicky Ferguson, which introduces the user to the patient scenario.**

medical students are provided during their interactions with SPs. The user can start interacting with the patient by clicking on the 'start simulation' button.

*3.3.2 Main System Interface.* Once the user starts the simulation, the main chat interface is initialized, shown in Figure 4. From here, the user can send messages to the patient (A), view the patient's electronic health record (B) and access a medical education assistant (C). Lastly, the user may ask for a hint via the light-bulb button (D). These 4 components are outlined in more detail below.

A. *Patient Agent Chat.* Within the main interface, the central component is the chat window for interactions with the patient agent. The user has the ability to switch between different patient cases or look back at their previous conversations by toggling the chat history button.
B. *Electronic Health Record (EHR) Sidebar.* This can be toggled via the hospital button on the top navigation. It consists of the patient's demographic information, their chief complaint (drawn from the patient stem), and other information relevant to their scenario. Depending on the type of case, this information could include vital signs, family history, allergies or medications. Below this, the user may take 'doctor's notes' which is common practice for medical students during SP interactions.
C. *Medical Education Assistant Sidebar.* The assistant can be toggled via the orange robot button on the top navigation. The user is able to ask specific questions about their interaction with the patient and receive feedback on their communication skills or get suggestions on things to ask. For example, in Figure 4, the user asks about red flags in a cough to help guide further questions for Sam.
D. *Medical Education Suggestion Button* The user can also ask for a 'hint' or suggestion using the light-bulb button. Unlike

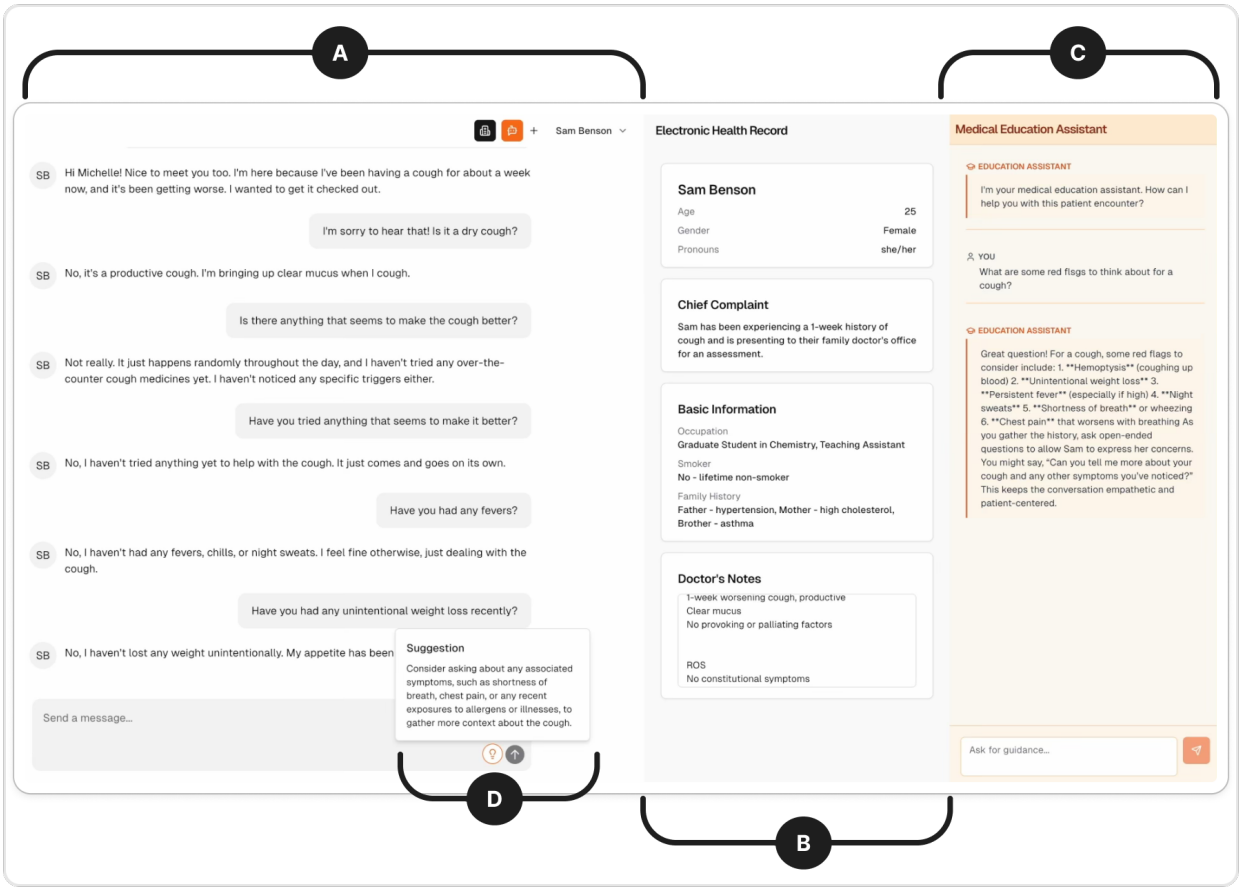


**Figure 4: The main interface of the Simulated Patient System, including the patient agent chat (A), electronic health record (EHR) sidebar (B), medical education assistant sidebar (C), and suggestion button (D)**

the education assistant, the suggestion button can help users when they feel stuck or don't know how to continue the conversation. For instance, after the user asked Sam about weight loss, it was unclear what should be asked about next. So, as shown in Figure 4, they pressed the suggestion button and were recommended to ask about shortness of breath, chest pain, etc. as those symptoms tend to be associated with coughs.

## 4 CONCLUSION AND FUTURE WORK

In this work, we have built an initial prototype of the simulated patient system, consisting of the patient agent and the educational assistant. We tested out different prompting techniques to create both components, and developed a user interface for medical students and professionals to interact with the system. As a part of the broader research project, we will continue building the rest of the system (outlined in Figure 1) in collaboration with an R1 research university's medical school and SP training program. This system's strengths lie in our direct collaboration with a university's SP training program, ensuring our cases are educationally relevant and integrate with existing workflows. The system is model-agnostic, allowing flexibility to swap LLMs as technology advances, and offers scalability to potentially include thousands of patient cases for medical education.

Our future work will involve three key studies in collaboration with our university's medical school. First, we will interview participants involved with the SP program to understand current workflows, pain points, and ways our system can augment existing practices. Based on this feedback, the finalized SP system will be evaluated for realism, consistency, and helpfulness with medical students and professionals. Finally, we will develop and assess a patient case co-creation tool to help case writers efficiently develop patient cases while minimizing biases. Ultimately, we hope to build a tool that can be used by medical students and professionals to improve their clinical communications skills, leading to better health outcomes for patients.

## ACKNOWLEDGMENTS

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