

# Prompt Engineering in Physics Education: Exploring the Use of ChatGPT

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# Context

- November 30, 2022 — the public launch of ChatGPT
    - Rapid rise of generative AI tools
    - Widely adopted by general public
  - Chatbots are becoming learning partners
    - NewtBot: Personalized automated tutor in Physics (Lieb & Goel, 2024)
    - ChatGPT: Not specialized, but commonly used (Ammari et al., 2025)
- How to ask a chatbot for the best answer?**
- Do chatbots answer differently at different student levels?**

# Prompt engineering (Spasić & Janković, 2023)

- Be as specific as possible in your instructions.
- Provide context and background information.
- Ask chatbot to break its work down into smaller parts.
- Ask chatbot to review and improve its response.

# Prompting patterns (White et al.; 2023)

- **The flipped interaction pattern:** The model asks questions first to better understand the task before answering.
- **The persona pattern:** The model takes on a specific role or identity to tailor its responses.
- **The question refinement pattern:** The model helps reframe or clarify the question to reach a more precise answer.
- ...

# Example of Question refinement pattern

I need help with physics on the topic of “electric field intensity.” I will ask you questions related to this topic. You will always offer me several improved formulations of my question, from which I will choose one, and then you will answer it.

Of course, I’ll be happy to help you with the topic of electric field intensity. Please ask me your first question, and I’ll offer you several improved formulations.

# Example of Question refinement pattern

What exactly is electric field intensity?

Here are several improved formulations of your question:

1. Can you explain what electric field intensity means?
2. What do we understand by the term electric field intensity?
3. How would we define electric field intensity?
4. What is electric field intensity and how is it measured?
5. What is the definition of electric field intensity in physics?

Which of these variants would you like to use?

# Research Aim and Methodology

- Focus on text-to-text prompting (no image or data input)
- GPT-3.5 and 4o (free versions)
- **Research question:** How does ChatGPT adapt its explanations when responding to students at different educational levels?
- Series of scenarios with the same query but different actors (lower secondary, upper secondary, and university student)
- Without vs. with applying prompt engineering principles
- Always using the Persona pattern

# Assignment without prompt engineering

I am a university student. Pretend you are my physics teacher. We are studying optics and I don't understand the concept of dispersion of light. Explain this concept to me.

Of course! Dispersion of light is a physical phenomenon in which white light is split into a spectrum of colors when passing through an optical medium, for example, a glass prism. This phenomenon occurs because different wavelengths of light travel at different speeds in a given medium.

...

# Response to simple prompts

- Short explanation of the topic
- Keeping the same structure of the answer (few paragraphs)
- ChatGPT is able to distinguish the level of understanding of individual actors
  - **Lower secondary:** simple concepts and approximations
  - **Upper secondary:** more precise explanation, essential information
  - **University:** professional terminology, general approach to the problem

# Response to simple prompts

## Lower secondary level

When light passes through, for example, a glass prism, its different colors (spectral components) are bent at different angles. This happens because each color has a different wavelength, and the glass is “transparent” differently for each color—it bends its direction by a different amount.

After passing through the prism, a spectrum of colors appears: red, orange, yellow, green, blue, indigo, and violet. This phenomenon is called **dispersion of light**.

**Have you ever seen a rainbow?** It is formed precisely thanks to dispersion—sunlight is split into a spectrum of colors in raindrops, similar to how it happens in a prism.

## Upper secondary level

This occurs when light passes through an optical medium where its speed changes depending on the wavelength.

We most often encounter dispersion when light passes through an optical prism. When white light enters a glass prism, each of its components (colors) is bent at a different angle. Blue light bends more than red light because it has a shorter wavelength and travels more slowly in glass. The result is a spectrum of colors, that is, a rainbow.

**An example of dispersion in nature** is a rainbow in the sky—it forms by the splitting of sunlight in water droplets in the atmosphere.

# Assignment with prompt engineering

I am a third-year student at an upper secondary school. Pretend you are my physics teacher. You have a PhD in physics and your main field is optics; you are very helpful and professional. I'm coming to you for help in understanding an optical phenomenon. It concerns the dispersion of light - I don't understand how it works. I also need a better explanation of what the color spectrum is. Please explain everything to me in detail and illustrate it with appropriate examples.

# Assignment with prompt engineering

I am a third-year student at an upper secondary school. Pretend you are my physics teacher. You have a PhD in physics and your main field is optics; you are very helpful and professional. I'm coming to you for help in understanding an optical phenomenon. It concerns the dispersion of light - I don't understand how it works. I also need a better explanation of what the color spectrum is. Please explain everything to me in detail and illustrate it with appropriate examples.

- Context information
- The Persona pattern
- Specifying the problem
- Additional requirement

# Response to prompts with prompt engineering

- ChatGPT once again distinguished between the individual actors
  - **Lower secondary:** use of analogy, emojis
  - **Upper secondary:** knowledge minimum, avoiding formulas
  - **University:** longer text, using formulas
- The length and quality of the response depends on whether the user follows the general recommendations for prompt engineering

# Summary

- ChatGPT can appropriately choose a didactic approach depending on the abilities of the given participants
  - In the prompt, it is important to specify the exact level of education
- The length and quality of the response depends on:
  - Following general guidelines for prompting
  - The use of prompt patterns

# Thank you for your attention!

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