

Ex.No.4-Scenario-Based Report Development Utilizing Diverse Prompting Techniques

REG NO : 212222220023

AIM:

To compare how different prompt patterns—Straightforward Prompting, Tabular Format Prompting, and Preceding Question Prompting—affect the outputs generated by three AI tools (ChatGPT, GitHub Copilot, and Google Gemini) in response to a factual question: **black hole formation and their key characteristics**.

AI TOOLS REQUIRED:

- ChatGPT
- Copilot
- Gemini

OBJECTIVES:

1. **To explore the variation in AI-generated content** across three different prompt styles (Straightforward, Tabular Format, and Preceding Question) and three different tools (ChatGPT, GitHub Copilot, and Google Gemini).
2. **To compare stylistic and thematic differences** in the responses across the AI tools when using each prompt style.
3. **To evaluate the scientific accuracy, clarity, and structure** of the responses provided by the different AI tools.
4. **To assess the ability of AI tools** to handle structured versus unstructured prompts and how each format influences the output quality.

PROCEDURE:

STEP 1: Scenario Definition

The scientific scenario for this experiment focuses on black holes:

- **Topic: "How do black holes form and what are their key characteristics?"**
This topic involves discussing the formation of black holes, their types, and their influence on their environment.

STEP 2: Prompt Pattern Design

Three distinct prompt styles are designed to examine how structured versus unstructured prompts influence the output. These prompts are:

1. **Straightforward Prompt:**
“How do black holes form and what are their key characteristics?”
2. **Tabular Format Prompting:**
“How do black holes form and what are their key characteristics? Please organize the answer into a table with two columns: Formation and Key Characteristics.”
3. **Preceding Question Prompting:**
“How do stars turn into black holes?
What are the different types of black holes?
How do black holes affect their surroundings?
Now, how do black holes form and what are their key characteristics?”

STEP 3: Tool Interaction

Each prompt pattern will be input into the three AI tools (ChatGPT, Copilot, and Gemini) separately. The tools will generate responses, which will be documented for evaluation.

STEP 4: Evaluation Criteria

The responses will be evaluated based on the following factors:

- **Scientific Accuracy:** Does the response accurately explain the scientific principles behind black hole formation and characteristics?
- **Clarity:** How clearly is the information presented? Are technical terms explained in a way that is understandable to a wide audience?

- **Structure:** How well is the response organized? For tabular prompts, is the table clear and informative? Does the narrative follow a logical progression?
- **Depth:** Does the response cover the topic comprehensively, touching on both formation and characteristics of black holes?
- **Adherence to Prompt:** Does the AI output address the prompt fully, and does it follow the format or structure requested (e.g., table, questions)?

STEP 5: Documentation and Comparison

The responses from each AI tool will be recorded, categorized by prompt type, and assessed based on the evaluation criteria. These responses will be analyzed to understand how each AI tool handles the same scientific question differently based on the prompt structure.

STEP 6: Analysis and Conclusion

The final analysis will summarize:

- The **performance of each AI tool** with respect to scientific accuracy, clarity, and depth of information.
- The **impact of the prompt style** on the quality and coherence of the responses.
- A **comparison of the tools' ability** to handle structured and unstructured prompts effectively.

PROMPT PATTERN DESIGNS

1. STRAIGHTFORWARD PROMPT:

"How do black holes form and what are their key characteristics?"

ChatGPT:

How Black Holes Form

Black holes form when massive stars (at least 3 times the mass of the Sun) run out of fuel and collapse under their own gravity, leading to a supernova explosion. If the core is heavy enough, it keeps collapsing into a point of infinite density, called a singularity, forming a black hole.

Key Characteristics

1. **Event Horizon:** The boundary beyond which nothing can escape, not even light.
2. **Singularity:** The center of the black hole, where density becomes infinite.
3. **Schwarzschild Radius:** The size of the event horizon, proportional to the black hole's mass.
4. **Time Dilation:** Time slows near the event horizon.
5. **No Hair Theorem:** Black holes are described only by three properties: mass, charge, and spin.
6. **Accretion Disk:** Matter swirling around the black hole, often emitting X-rays as it heats up.
7. **Spin:** Black holes can rotate, affecting nearby spacetime.

Types of Black Holes

1. **Stellar-Mass:** Form from collapsing stars.
2. **Supermassive:** Found at galaxy centers, millions to billions of times the Sun's mass.
3. **Intermediate:** Mid-sized, harder to detect.
4. **Primordial:** Hypothetical small black holes formed in the early universe.

COPILLOT:

Black holes form when massive stars reach the end of their life cycles and undergo gravitational collapse. Here's how it happens:

Formation:

1. **Stellar Death:** When a massive star (usually more than 20 times the mass of the Sun) exhausts its nuclear fuel, it can no longer counteract the force of gravity.
2. **Supernova Explosion:** The outer layers of the star are expelled in a spectacular supernova event, while the core collapses inward.
3. **Gravitational Collapse:** If the remaining core is massive enough (typically above about 3 solar masses), it collapses into an infinitely dense point called a singularity, forming a black hole.

Key Characteristics:

- **Event Horizon:** The boundary beyond which nothing—not even light—can escape. This marks the "point of no return."
- **Singularity:** A region of infinite density at the core, where gravity is so strong that the laws of physics break down.
- **Extreme Gravity:** Black holes warp space and time around them, creating gravitational time dilation effects.
- **Accretion Disk:** When matter falls toward a black hole, it forms a superheated disk of gas and dust that emits intense radiation.
- **Hawking Radiation (Hypothetical):** Theoretical quantum effects suggest that black holes can slowly evaporate by emitting tiny amounts of radiation.

Black holes come in different types, including **stellar-mass black holes**, **supermassive black holes (found at the centers of galaxies)**, and **intermediate-mass black holes**, which bridge the gap between the two.

GEMINI:

Black holes form from the collapsed cores of massive stars after a supernova, or through other processes for supermassive and primordial black holes. Their key features include an **event horizon** (the point of no return), a central **singularity** (where mass is concentrated), **mass**, potential **charge**, and **angular momentum (spin)**. While invisible, their presence is detected through their gravitational effects and the radiation from surrounding **accretion disks**.

2. TABULAR FORMAT PROMPTING:

"How do black holes form and what are their key characteristics? Please organize the answer into a table with two columns: Formation and Key Characteristics."

ChatGPT:

FORMATION

Stellar Collapse: A black hole forms when a massive star, typically more than 20 times the mass of the Sun, exhausts its nuclear fuel and undergoes gravitational collapse. The core contracts, and the outer layers are expelled, leading to the formation of a singularity surrounded by an event horizon.

Supernova Explosion: The collapse often occurs after a supernova explosion, leaving behind a remnant core that collapses into a black hole.

Accretion of Matter: Black holes can also form through the accretion of mass from a companion star or from the merging of smaller black holes.

Primordial Black Holes: These are hypothetical black holes that may have formed in the early universe due to high-density fluctuations.

Merging of Black Holes: When two black holes in a binary system orbit each other closely, they can eventually spiral inwards and merge, forming a larger black hole.

KEY CHARACTERISTICS

Singularity: The center of the black hole where the density becomes infinite and spacetime curvature reaches extreme values.

Event Horizon: The boundary surrounding the black hole beyond which nothing, not even light, can escape.

Spacetime Curvature: The immense gravity of a black hole causes significant warping of spacetime, affecting the motion of nearby objects.

Hawking Radiation: Predicted by physicist Stephen Hawking, this phenomenon suggests that black holes can emit radiation due to quantum effects near the event horizon, slowly causing them to lose mass and eventually evaporate.

No Hair Theorem: Black holes are characterized only by their mass, electric charge, and spin, with no other distinguishing features visible from the outside.

COPILOT:

FORMATION

Black holes form when a massive star (typically more than 20 times the mass of the Sun) exhausts its nuclear fuel. Without the outward pressure from fusion, gravity causes the star to collapse inward.

If the collapsing core has enough mass, it compresses into an infinitely dense singularity, where the laws of physics as we know them break down.

Smaller black holes can also form through extreme conditions like collisions or the merging of neutron stars.

Supermassive black holes, millions to billions of times the mass of the Sun, may form through the merging of smaller black holes or the direct collapse of massive gas clouds.

Scientists also theorize that primordial black holes could have formed shortly after the Big Bang due to extreme density fluctuations in the early universe.

KEY CHARACTERISTICS

Black holes have an event horizon, which is a boundary beyond which nothing—not even light—can escape.

They exhibit immense gravitational pull, affecting nearby stars, planets, and even light itself.

Black holes come in different sizes: stellar-mass, intermediate-mass, and supermassive black holes (which exist at the centers of galaxies).

Time behaves differently near black holes due to intense gravitational time dilation, slowing down relative to distant observers.

Some black holes emit powerful jets and X-rays as matter spirals in and heats up before crossing the event horizon.

GEMINI:

Black holes are truly fascinating cosmic objects! They form through the dramatic collapse of massive stars or the merging of neutron stars, resulting in regions of spacetime where gravity is so intense that nothing, not even light, can escape. Here's a table summarizing their formation and key characteristics:

FORMATION

Stellar Collapse: When massive stars (significantly larger than our Sun) reach the end of their lives, they can no longer support themselves against their own gravity. Their cores collapse inward catastrophically during a supernova explosion, squeezing the matter into an incredibly small volume. If the remaining core's mass exceeds a certain limit (the Tolman–Oppenheimer–Volkoff limit, typically around 2-3 times the mass of our Sun), gravity overwhelms all other forces, leading to the formation of a stellar-mass black hole.

Neutron Star Merger: When two neutron stars in a binary system spiral inward and collide, the resulting object can sometimes have enough mass to exceed the Tolman–Oppenheimer–Volkoff limit, leading to the formation of a black hole. This process is also thought to be a significant source of gravitational waves.

KEY CHARACTERISTICS

Event Horizon: This is the "point of no return" surrounding a black hole. It's not a physical surface but rather a boundary in spacetime. Anything that crosses the event horizon, including light, is trapped forever and cannot escape the black hole's gravitational pull. The size of the event horizon is determined by the black hole's mass.

Singularity: At the very center of a black hole lies the singularity, a theoretical point of infinite density where all the black hole's mass is concentrated. Our current understanding of physics breaks down at the singularity.

Supermassive Black Hole Formation: The formation mechanisms for supermassive black holes (SMBHs), found at the centers of most galaxies and boasting masses millions to billions of times that of our Sun, are still an active area of research. Leading theories include the direct collapse of massive gas clouds, the merging of smaller black holes, and the runaway growth of stellar-mass black holes through accretion.

Mass: Black holes possess mass, which determines the strength of their gravitational pull and the size of their event horizon (Schwarzschild radius, proportional to mass: $(R_s = \frac{2GM}{c^2})$). Stellar-mass black holes typically range from a few to tens of solar masses, while supermassive black holes can be billions of solar masses. Intermediate-mass black holes, with masses between these two extremes, are less common but have been detected.

Spin (Angular Momentum): Some black holes rotate, a characteristic inherited from the original star or the dynamics of their formation. A spinning black hole has a more complex structure than a non-rotating one and can have an "ergosphere," a region outside the event horizon where it's impossible to remain stationary.

Charge: While black holes can theoretically possess an electric charge, it is expected to be quickly neutralized by attracting oppositely charged particles from the surrounding environment. Therefore, astrophysically relevant black holes are generally considered to be uncharged or to have negligible charge.

3. PRECEDING QUESTION PROMPTING:

**"How do stars turn into black holes?
What are the different types of black holes?"**

How do black holes affect their surroundings?

Now, how do black holes form and what are their key characteristics?"

ChatGPT:

1. How do stars turn into black holes?

Massive stars (at least 20 times the Sun's mass) collapse after exhausting their fuel, triggering a supernova explosion. If the remaining core is massive enough (about 3 times the Sun's mass), it collapses into a black hole.

2. What are the different types of black holes?

- Stellar black holes: Form from dying massive stars (3–10 times Sun's mass).
- Supermassive black holes: Found in galaxy centers, with masses millions to billions of times the Sun's mass.
- Intermediate black holes: Between stellar and supermassive black holes.

3. How do black holes affect their surroundings?

- Accretion disks: Matter spirals in, emitting high-energy radiation.
- Gravitational lensing: Bends light, distorting distant objects.
- Jets: Some black holes shoot out high-speed particles.
- Time dilation: Time slows near the event horizon.

4. How do black holes form and what are their key characteristics?

Black holes form from star collapse or mergers. Key features:

- Event horizon: The point beyond which nothing can escape.
- Singularity: A point of infinite density at the center.
- Mass and spin: The two main properties of a black hole.

COPILLOT:

Black holes form when massive stars collapse under gravity, creating an incredibly dense singularity.

Types of Black Holes

- **Stellar:** Formed from dying stars (3–100 times the Sun’s mass).
- **Supermassive:** Found in galaxy centers (millions to billions of times the Sun’s mass).
- **Intermediate:** Between stellar and supermassive.
- **Primordial:** Hypothetical tiny black holes from the early universe.

Effects on Surroundings

- Warp space and time.
- Pull in matter, forming hot **accretion disks**.
- Emit powerful **jets** of particles.
- Stretch objects into long strands (**spaghettification**).

Key Features

- **Event Horizon:** Point of no return.
- **Singularity:** Infinite density.
- **Time Dilation:** Slows time near the black hole.
- **Absorbs Light:** Makes them invisible unless interacting with matter.

GEMINI:

How do stars turn into black holes? Massive stars exhaust their fuel, their cores collapse, and if the remaining core is massive enough (over 2-3 solar masses), gravity crushes it into a black hole during a supernova.

What are the different types of black holes? Stellar-mass (few to tens of solar masses), intermediate-mass (hundreds to thousands of solar masses), supermassive (millions to billions of solar masses), and hypothetical primordial black holes.

How do black holes affect their surroundings? Through intense gravity, causing orbital motion and tidal forces. They can form hot, radiating accretion disks and powerful jets of plasma. Merging black holes also create gravitational waves.

Now, how do black holes form and what are their key characteristics?

FORMATION

KEY CHARACTERISTICS

Massive Star Collapse: Core of a dying massive star ($>8M_{\odot}$) collapses after supernova if remnant mass exceeds $\sim 2-3M_{\odot}$.

Event Horizon: Boundary where escape velocity equals the speed of light; nothing escapes beyond it. Size depends on mass. Neutron Star Merger: Collision of two neutron stars can result in a black hole if the total mass exceeds the limit.

Supermassive Black Hole Formation: Mechanisms still researched; may involve direct gas collapse, black hole mergers, and accretion at galactic centers.

Mass: Ranges widely from a few solar masses to billions. Determines gravitational pull and event horizon size ($R_s \propto M$).

Spin: Some black holes rotate (Kerr black holes), influenced by the progenitor star or formation dynamics. Rotating black holes have an ergosphere.

Charge: Astrophysical black holes are generally considered to be uncharged or have negligible charge due to neutralization by surrounding particles.

ANALYSIS AND CONCLUSION:

Performance of AI Tools:

- **ChatGPT** performed exceptionally well in all scenarios. It provided detailed, scientifically accurate, and well-structured responses. It was especially good at elaborating on complex concepts and providing depth.
- **GitHub Copilot** showed strong performance, though it leaned more toward concise bullet points and was slightly less in-depth than ChatGPT. It was well-organized and provided accurate answers but had fewer details.
- **Google Gemini** was clear and concise, but its responses were more compact and less detailed compared to the other two tools. While it captured the essential points, it lacked the depth and exploration provided by ChatGPT.

Impact of Prompt Style:

- **Straightforward Prompt** produced clear and direct responses, but it limited the tools in terms of structure and details.
- **Tabular Format Prompting** encouraged more structured and organized responses, allowing for easier comparison. It worked well for all tools, though some, like ChatGPT, provided more

in-depth information.

- **Preceding Question Prompting** helped the tools break down the topic into smaller segments, which allowed for detailed exploration of each aspect of black holes. It was beneficial for all tools but resulted in slightly more fragmented responses.

Conclusion:

- **ChatGPT** excelled across all metrics, providing both depth and clarity.
- **GitHub Copilot** offered solid, concise responses with moderate depth.
- **Google Gemini** delivered clear and direct answers but lacked depth compared to ChatGPT.