AI Case Studies –
GPS, ELIZA, Student, Macsyma

F24 – Artificial Intelligence & MMG

Faculty of Emerging Sciences & Technologies

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Purpose of the AI Case Studies

These classic case studies — GPS, ELIZA, STUDENT, and MACSYMA — were designed to test and explore different aspects of human intelligence (like reasoning, language, problem-solving, and learning) using computers.

Each one was a research experiment that tried to answer question:

“Can a computer think or reason like a human in this specific way?”

These case studies were early experiments designed to explore:

1. Can machines **reason** like humans? → *(GPS)*
2. Can machines **talk** like humans? → *(ELIZA)*
3. Can machines **understand language and logic**? → *(STUDENT)*
4. Can machines **solve mathematical problems symbolically**? → *(MACSYMA)*

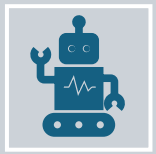
1. GPS (General Problem Solver)

- **Main Purpose:** To test whether a computer could **reason logically** and solve *wide range of well-defined problems* using general strategies — just like a human thinker.

- **Goal of the Case Study:**
  - To explore **human problem-solving processes.**

- **Why it was important:** GPS showed that computers can use **search-based reasoning** — the foundation of modern AI planning systems, pathfinding, and robotics.

1. GPS (General Problem Solver)



Developed by: Allen Newell & Herbert A. Simon (1957)

Purpose: GPS was designed to **mimic human problem-solving** by breaking down complex problems into smaller, manageable steps — much like how humans think.

How it worked: GPS used a concept called **means–ends analysis**.
It compared the **current state** and the **goal state**, then tried to find actions that reduce the difference between them.

1. GPS (General Problem Solver)

- **Example/Analogy:** Imagine you're trying to reach the top of a mountain.
  - The *current state* is "base of the mountain."
  - The *goal state* is "mountain top."
    GPS would identify intermediate steps (climb to midpoint, rest, continue, etc.) to reach the goal efficiently.

- **Significance:** GPS was an early attempt to create a **universal reasoning machine**, one that could solve any logical problem, such as logic puzzles, algebra, or proofs, using the same general strategy.

- **In Real-life:**
  Modern **automated planners** and **AI algorithms** used in logistics and robotics are descendants of GPS.

2. ELIZA

To test if a computer could **simulate human conversation** using language — even without true understanding.

Goal of the Case Study: To study how machines process and respond to human language.

To see how people emotionally respond to a computer.

Why it was important: ELIZA showed that even simple pattern matching could make humans *believe* a machine understands them.

2. ELIZA

- **Developed by:** Joseph Weizenbaum (1966)
- **Purpose:** ELIZA was an early **natural language processing (NLP)** program that simulated a **therapist** by holding typed conversations with humans.
- **How it worked:** ELIZA followed simple **pattern-matching rules**. When users typed something like

  “I’m feeling sad today,”
  ELIZA might reply,
  “Why do you think you are feeling sad today?”
- It didn’t actually understand language — it just used **predefined patterns** to generate human-like responses.

2. ELIZA

Analogy: Think of ELIZA doesn't understand the meaning of words but mimics conversation — like a parrot that repeats sentences in a contextually fitting way.

Importance: ELIZA was the **first chatbot** and proved that humans could be *fooled* into believing a machine was intelligent.

It inspired the idea of **human–computer conversation**, forming the basis for Siri, Alexa, and ChatGPT.

3. STUDENT

- **Main Purpose:** To demonstrate that a computer could **understand English sentences** well enough to solve **mathematical problems.**
- **Goal of the Case Study:** To test early **language understanding** — turning words into logic or equations.

  To see if a computer could “comprehend” meaning, not just repeat patterns.

- **Why it was important:** It proved that AI could *bridge language and logic* — the basis of intelligent tutoring systems which can solve word problems or math queries from text.

3. STUDENT

- **Developed by:** Daniel G. Bobrow (1964, MIT)
- **Purpose:** STUDENT was a **natural language understanding system** that could solve **algebra word problems** given in English.
- **How it worked:** It translated sentences like

“If the number of customers is twice the number of employees, and there are six customers, how many employees are there?” into mathematical equations and solved them.

3. STUDENT

- **Analogy:** STUDENT worked like an interpreter — converting *English sentences* into *math equations*, solving them, and then replying in English.

- **Importance:** It demonstrated not just matching words, but grasping relationships and logic behind sentences.

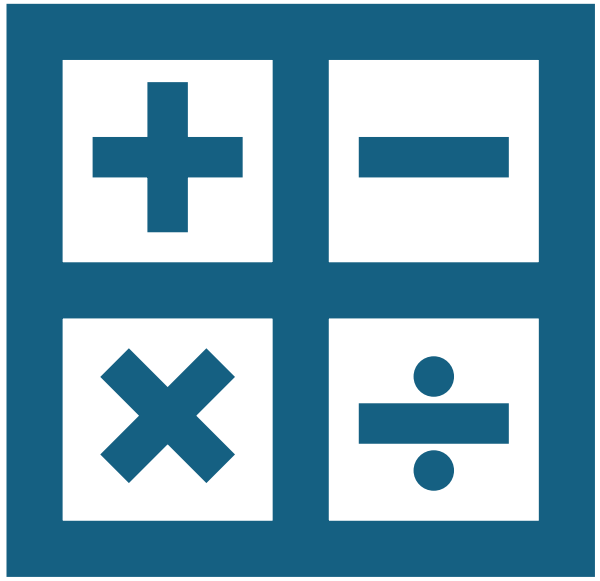
  This project laid the groundwork for **AI in education**, **intelligent tutoring systems**, and tools like WolframAlpha.

4. MACSYMA (Project MAC's SYmbolic MAnipulator)

Main Purpose: To explore how AI can perform **symbolic mathematical reasoning** — manipulating symbols the way humans do in algebra or calculus.

Goal of the Case Study: To test **symbolic computation**
To develop a tool that can do calculus, simplify equations, and derive results automatically.

Why it was important: MACSYMA became a **powerful mathematical engine** that inspired software like **Mathematica** and **Maple** used in science, engineering, and research.



4. MACSYMA (Project MAC's SYmbolic MAnipulator)

- **Developed by:** MIT Project MAC, late 1960s
- MACSYMA was an advanced **symbolic mathematics program** — capable of doing calculus, algebra, limits, and differential equations symbolically (not just numerically).
- **How it worked:** It could perform operations such as differentiating or integrating equations, simplifying expressions, and even solving symbolic equations.
- **Example:** If you entered:

  Differentiate $x^2 + 3x + 2$
  MACSYMA would output:
  $2x + 3$

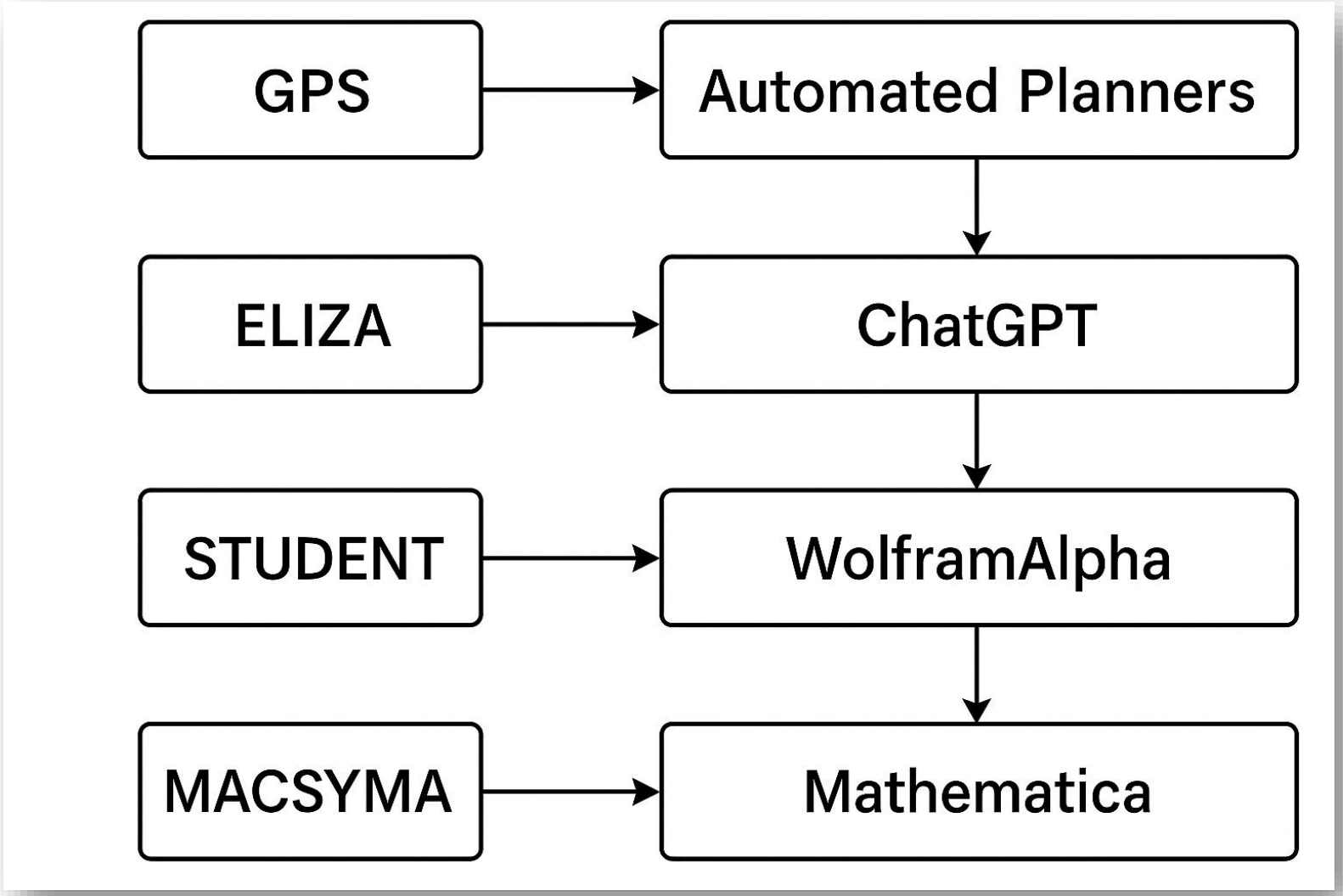
4. MACSYMA (Project MAC's SYmbolic MAnipulator)

- **Analogy:** Imagine MACSYMA as the *ancestor of MATLAB's symbolic toolbox*. It was like having a virtual mathematician who never tired.

- **Significance:** MACSYMA was one of the **most successful early AI programs** — combining mathematical logic, algebraic manipulation, and symbolic reasoning.

Summary Table

Case Study	Developer(s)	Main Function	Key Idea/Method	Modern Analogy
GPS	Newell & Simon (1957)	General problem solver	Means–Ends Analysis	Automated planners, optimization algorithms
ELIZA	Weizenbaum (1966)	Chatbot simulating conversation	Pattern Matching	Siri, ChatGPT
STUDENT	Bobrow (1964)	Solving algebra word problems	Semantic Parsing	WolframAlpha, AI tutors
MACSYMA	MIT (1960s)	Symbolic mathematics	Algebraic Reasoning	Mathematica, Maple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