CMPUT 267
Machine Learning I

Instructor: Dieter Büchler

Classes and review sessions will be streamed on Google Meet

Classes Will be Recorded

- Classes and review sessions will be recorded
- Recordings will be posted on eClass
- If you speak (ex: ask a question) in class your voice will be recorded
- If you speak on Google Meet your voice and Google profile picture (or video if you have it on) will be recorded.
- Note that lectures may be audio recorded for the purpose of a student's individual study as per their approved academic accommodation.

Team

TA email: cmput267@ualberta.ca

Name	Day and Time	Location
Bahar Boroomand Ghahnavieh	Monday 9:00am - 10:00am	Virtual
Zijun Wu	Monday 2:00pm - 3:00pm	Virtual
Armin Ashrafi	Tuesday 8:00am - 9:00am	ATH-01
Xinze Xiong	Tuesday 1:00 - 2:00pm	CSC 3-50
Siddarth Chandrasekar	Wednesday 10:00am - 11:00am	CAB 313
Mohamed Mohamed	Wednesday 1:00pm - 2:00pm	Virtual
Duc Thang Chu	Thursday 9:00am - 10:00 am	Virtual
Vlad Tkachuk	Thursday 12:00pm - 1:00pm	Virtual
Dieter Büchler (Instructor)	Thursday 3:30pm - 4:30pm	ATH 3-42
Guoqing Luo	Friday 9:00am - 10:00am	Virtual
Andrew Luke Freeman	Friday 12:00pm - 1:00pm	Virtual
Lucas de Araujo Cruz	Friday 2:00pm - 3:00pm	CSC 3-50

About me

- Dieter Büchler
- married & 2 kids
- research on robot learning and soft/muscular robots
- started as an Assistant Prof in Oct 2024
- BSc in Electrical Engineering (HAW Hamburg, GER)
- MSc in Biomedical Engineering (Imperial College London, UK)
- PhD in Computer Science (MPI for Intelligent Systems & TU Darmstadt, GER)

There is a course website

(dtrb.github.io/machinelearning1)

These slides (and future) are posted there in the schedule tab

Course is based on the (in progress) course notes

They might be slightly updated throughout the term

Course Details

- Lectures: Tue & Thu 2:00pm - 3:20pm (ETLC E1-001 & Virtual)
  - Will go over course notes
- Review sessions (Optional):
  - Assignments: Monday after due date
  - Midterm exams: Friday same week of the midterm
  - Students can vote for the
  - Done by the TAs remotely
- Instructor: Dieter Büchler (email: dieter.buechler@ualberta.ca)
- Office Hours: Thu 3:30pm - 4:30pm (ATH 3-42)

Asking Questions and Getting Help

1. **Ask an LLM** (ex: ChatGPT). Fast responses and familiarizes you with LLMs.
   - **IMPORTANT:** LLM outputs should not be blindly trusted; students must verify information if unsure of its accuracy.
2. **Ask on Piazza** (Note: you can ask questions anonymously)
   - Any questions that don't reveal assignment solutions
3. **Email the TAs** (cmput267@ualberta.ca)
   - For private assignment questions
4. **Email the instructor** (dieter.buechler@ualberta.ca)
   - Missing exams or personal issues

Join Piazza
(Link also on eClass and course website)

Grading

Assessment	Weight	Date
Assignments (8, top 7 counted):	25% (3.57% each)	See the schedule tab on the course website
Midterm exam 1:	22.5 %	Feb 11, 2025 in class (2:00pm - 3:15pm in ETLC E1-001)
Midterm exam 2:	22.5 %	Mar 25, 2025 in class (2:00pm - 3:15pm in ETLC E1-001)
Final exam	30 %	Apr 23, 2025 (3 hours, starts at 1:00pm), date and time

- At least 3 of the assignments will be coding assignments. We will be using Python in Google Colab.
- To do the assignments you will need: An internet connection, and a modern web browser (Chrome, Firefox, or Safari recommended).

Course Policies

- We will not accept late assignments
- If you are granted an excused absence for a midterm exam its weight will be transferred to the final exam
- All assignments must be written by you in your own words
- You can use AI (ex: LLMs) to **help you** with assignments
  - You will not lose marks for using AI, unless you used AI to generate a complete solution for you
- No cheating, plagiarism, harassment, physical assault, etc.
  - Can result in suspension or expulsion from the University
  - Familiarize yourself with the new Student Academic Integrity Policy

Refer to the syllabus for detailed official course policies

Advice: If you can do the assignment questions and examples in the course notes,

then you are likely to succeed on the midterms and final exam

Disclaimer: This course is math heavy, and we cover neural networks only towards the end of the course

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However: Course notes are mostly self contained and I will try to motivate things as much as possible

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Necessary background: Can take derivatives (Calculus)

Useful background: Probability and statistics, familiar with vectors and matrices (Lin Alg)

Please ask questions!

Especially: “Why are we doing this?”

Course Outline

1. Math and probability review
2. Define supervised learning formally (splitting it into regression or classification)
3. Design some learning programs to solve regression problems

   Midterm Exam 1
4. Evaluate our learning programs
5. Present some new ways to design learning programs for regression

   Midterm Exam 2
6. Repeat the above for classification problems
7. Intro to neural networks / large language models

   Final Exam (Cumulative)

What is Machine Learning?

What is Machine Learning?

Remaining slides are inspired by: Shai Ben-David (Lecture 1 - CS 485/685)

Raise your hand if you think you know what Machine Learning is

Raise your hand if you learned about machine learning before

(ex: taken a course, watched videos, etc.)

Raise your hand if you've heard of:

Raise your hand if you use:

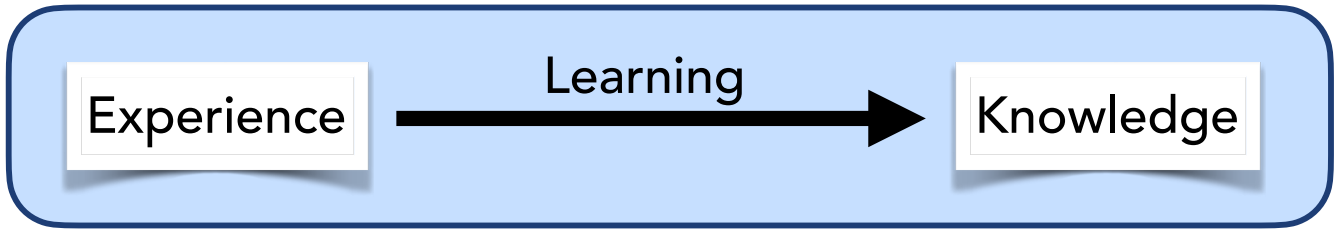
Raise your hand if you think Machine Learning is exciting

What is Machine Learning?

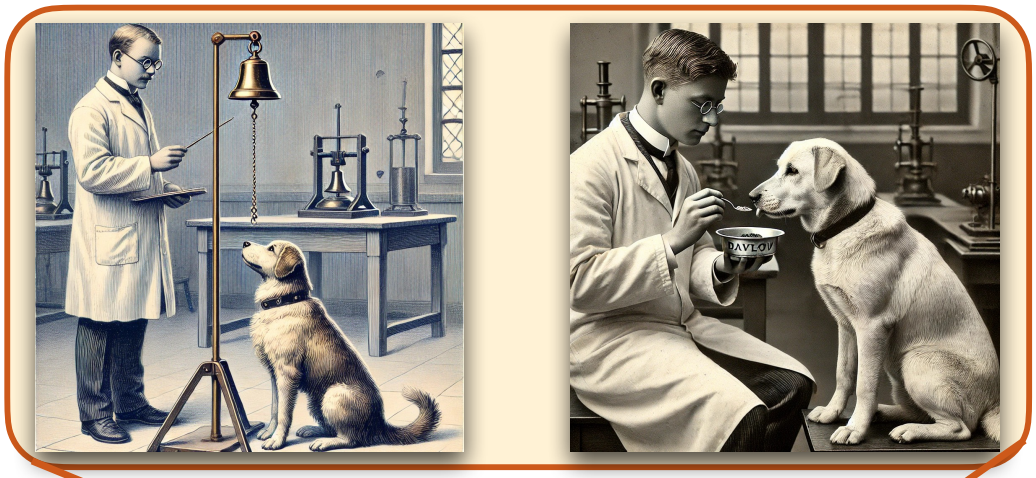
What is Machine Learning?

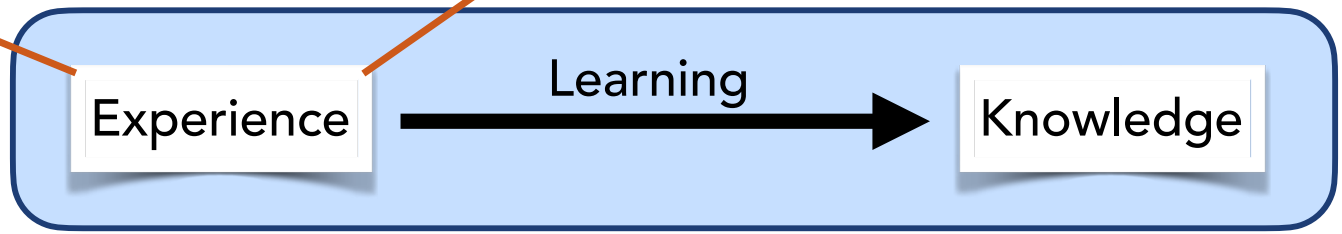
Answer: A program/algorithm that is learning

What is Learning?


Experience
Learning
Knowledge

Example: Pavlov's Dog





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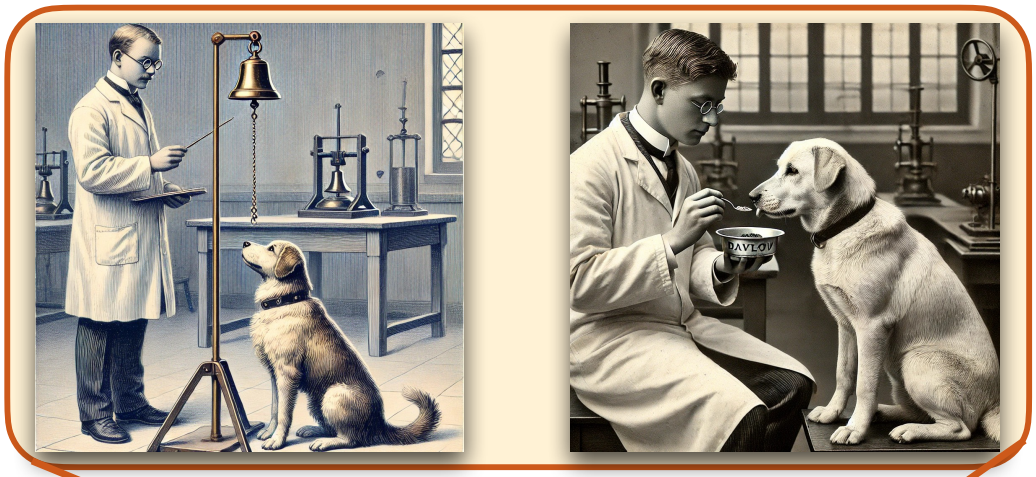
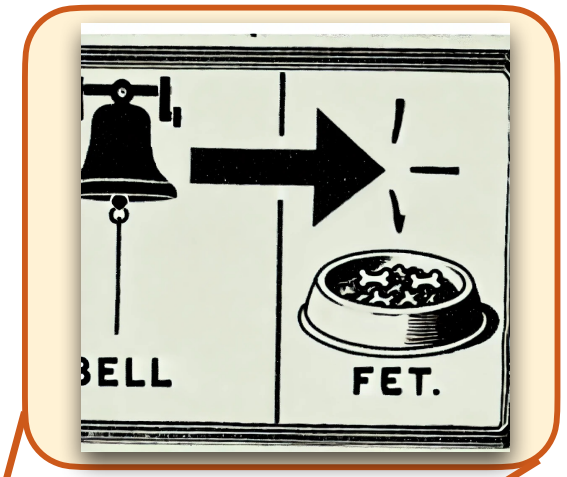
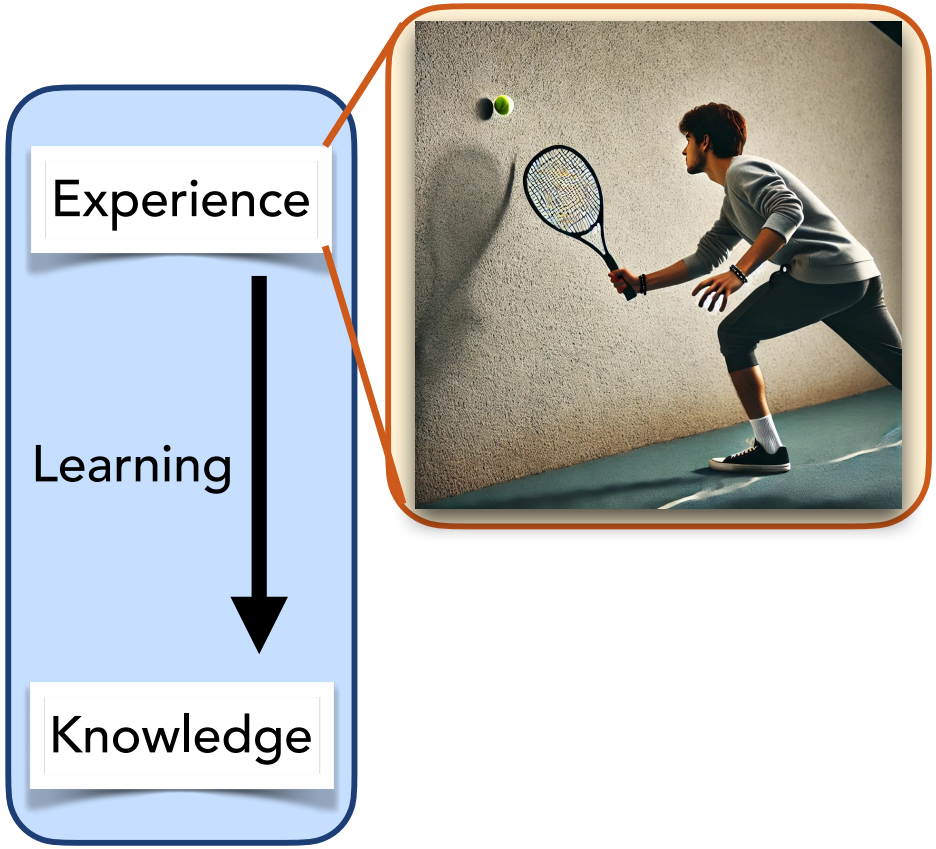




Experience → Learning → Knowledge

Example: Learning to Play Tennis



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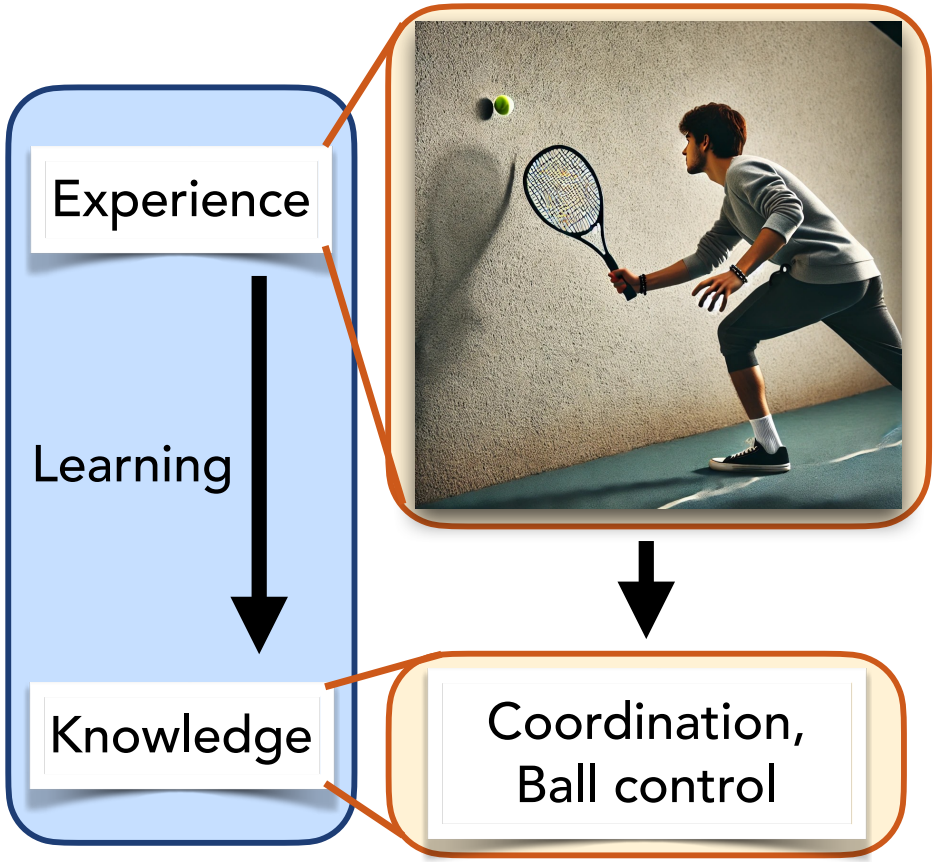

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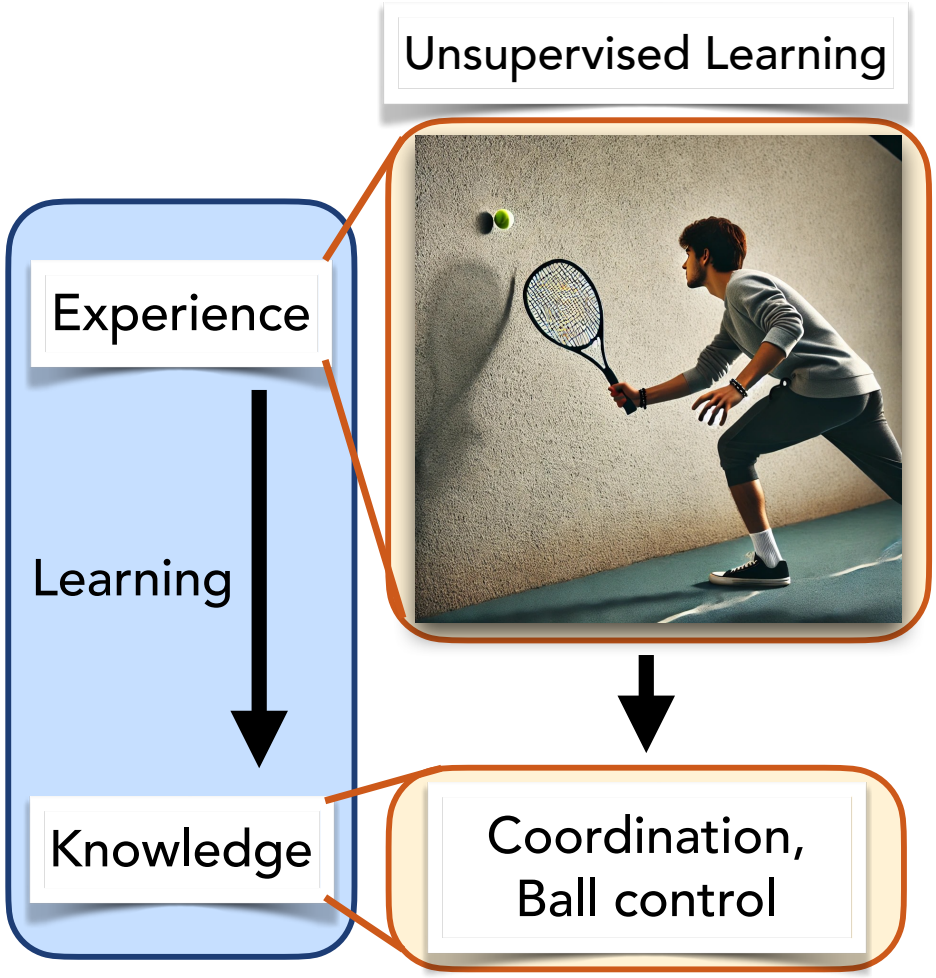

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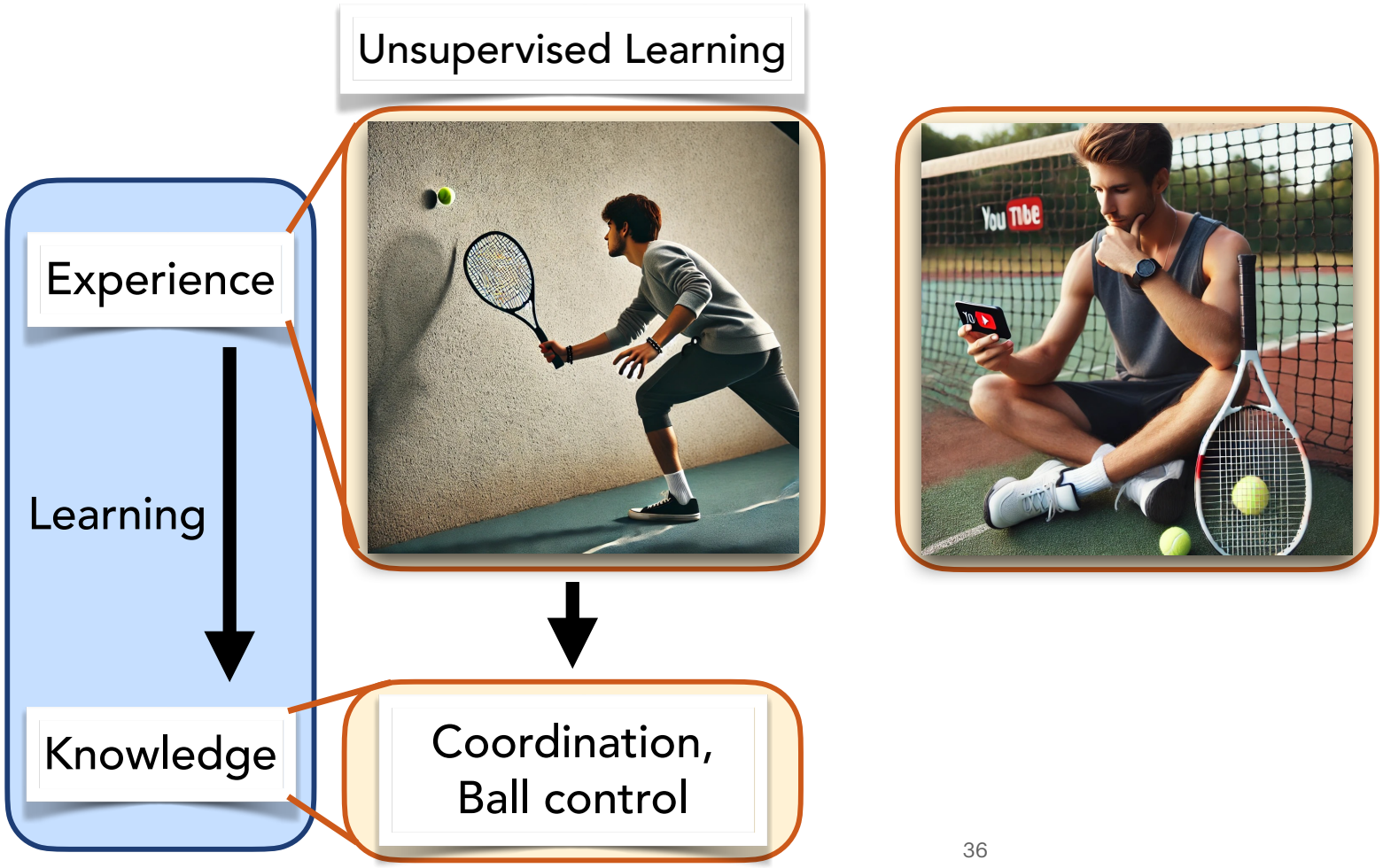

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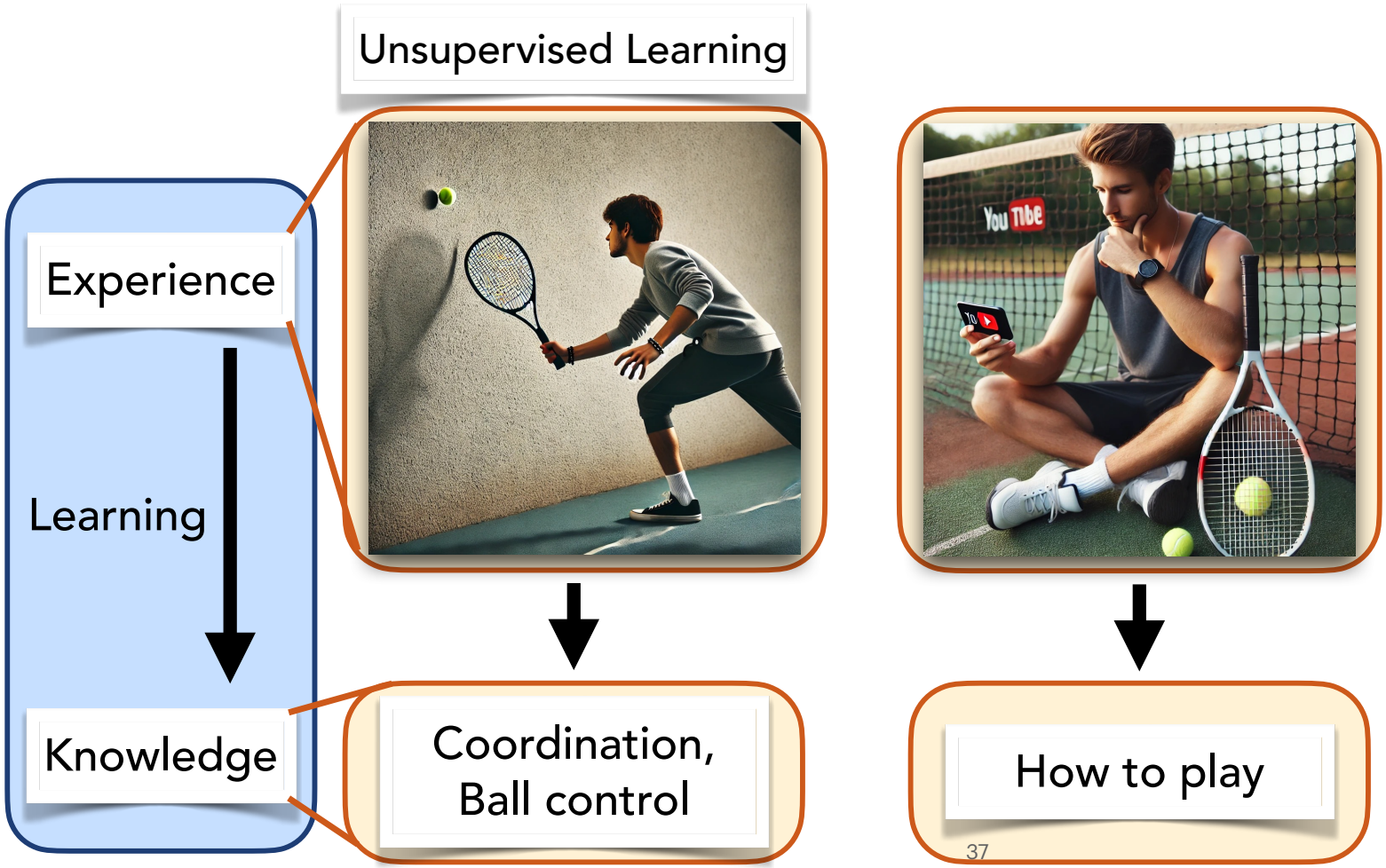

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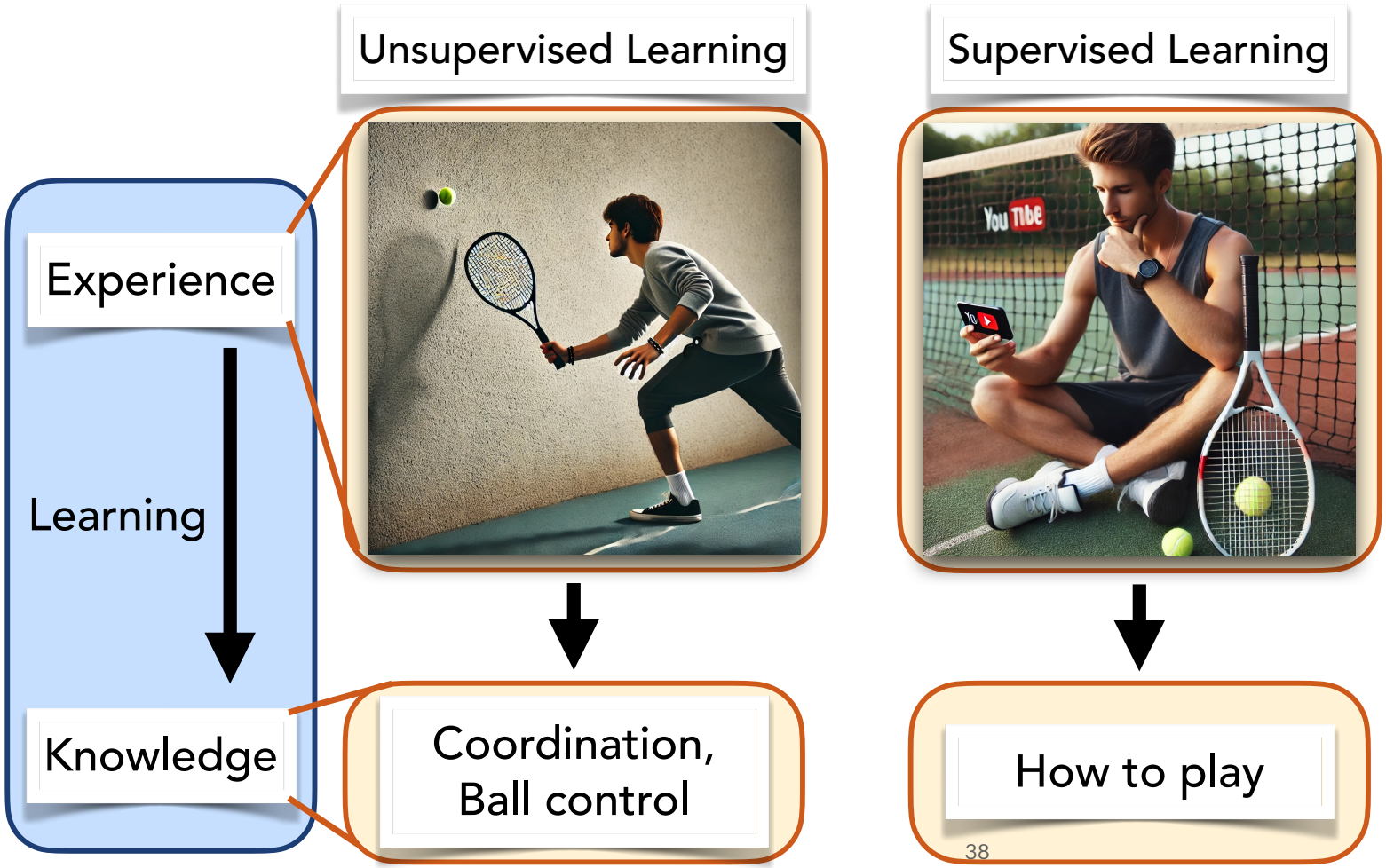

Example: Learning to Play Tennis

Unsupervised Learning

Supervised Learning

Experience

Learning

Knowledge

Coordination,
Ball control

How to play

Example: Learning to Play Tennis

Unsupervised Learning

Supervised Learning

Experience

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Example: Learning to Play Tennis

Experience

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Knowledge

Unsupervised Learning

Coordination, Ball control

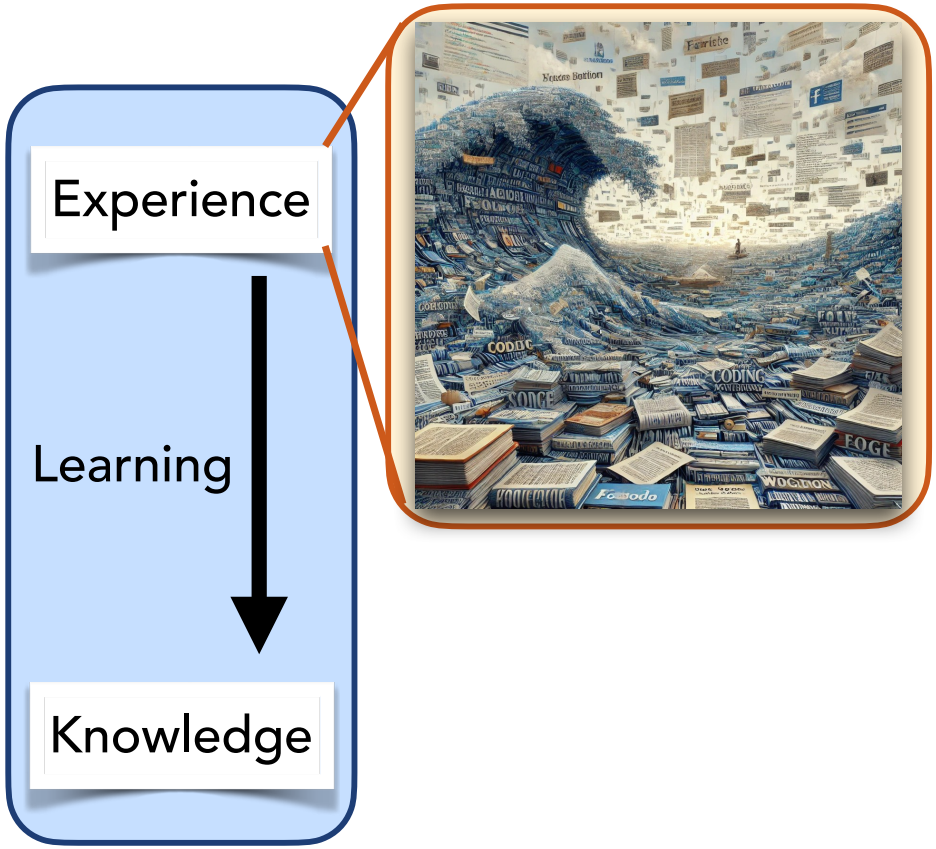
Supervised Learning

How to play

Reinforcement Learning

How to play

Example: Learning Language



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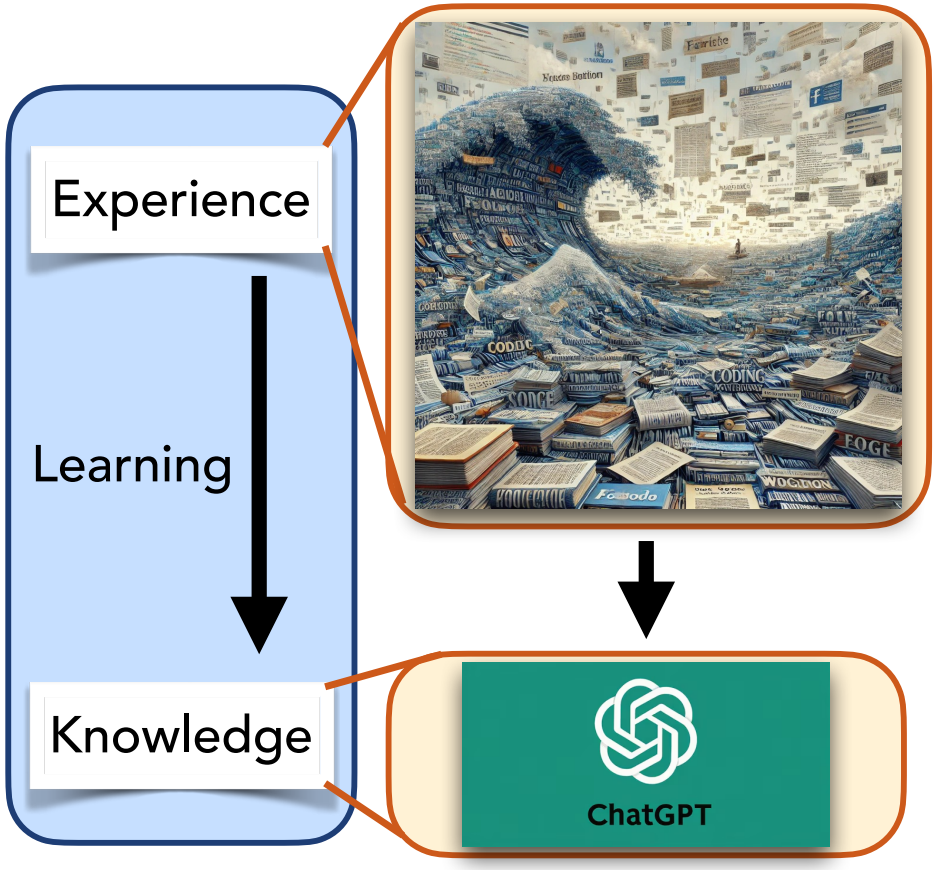

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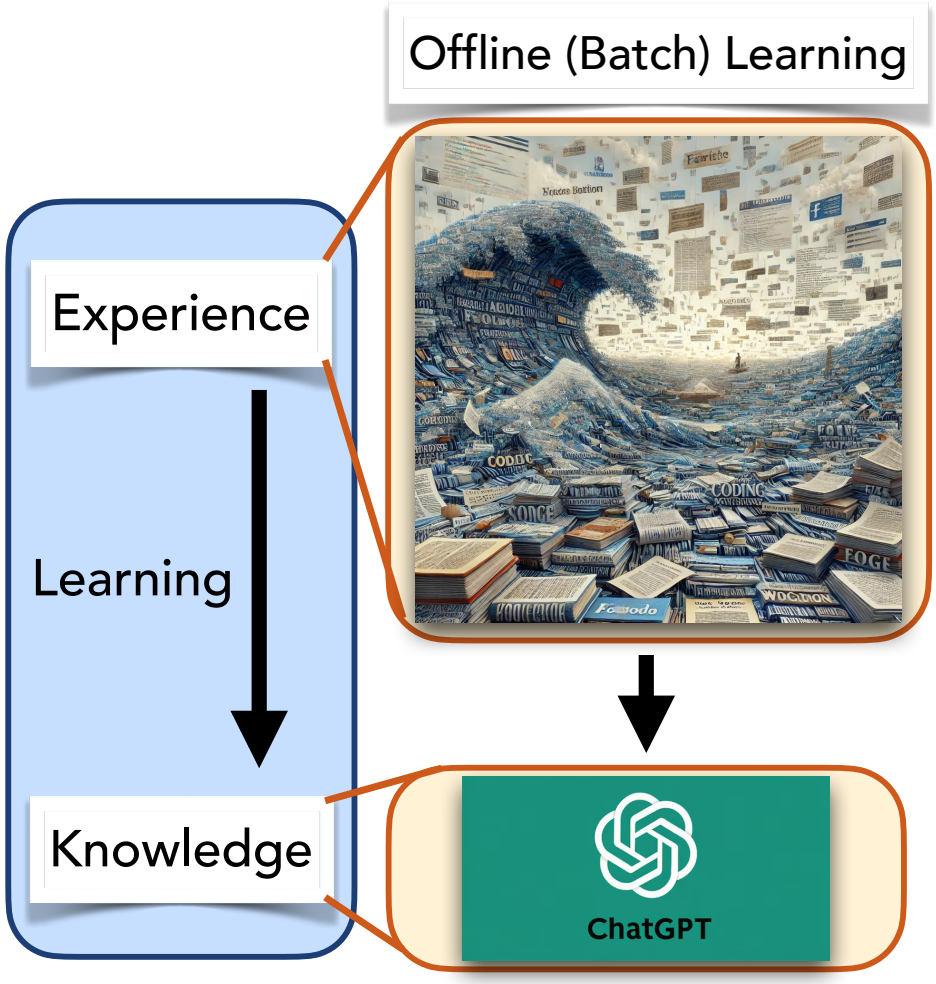

Example: Learning Language

Offline (Batch) Learning

Experience

Learning

Knowledge

ChatGPT

Example: Learning Language

Offline (Batch) Learning

Experience

Learning

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Example: Learning Language

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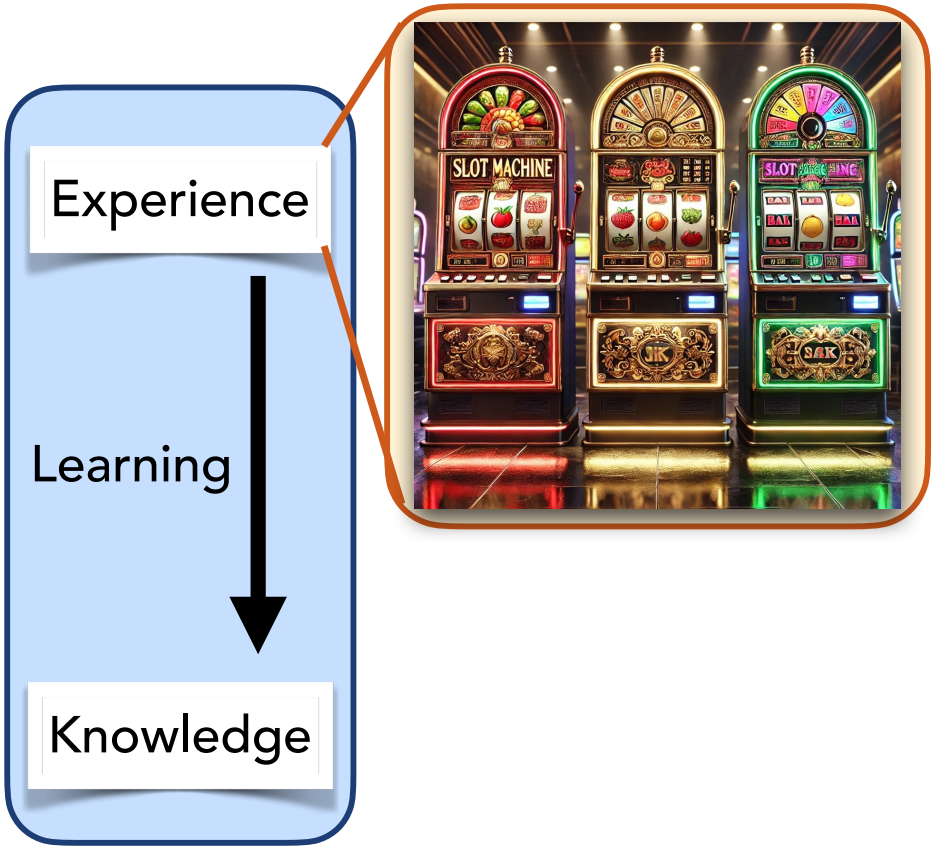
Offline (Batch) Learning

ChatGPT

Online Learning

Example: Games



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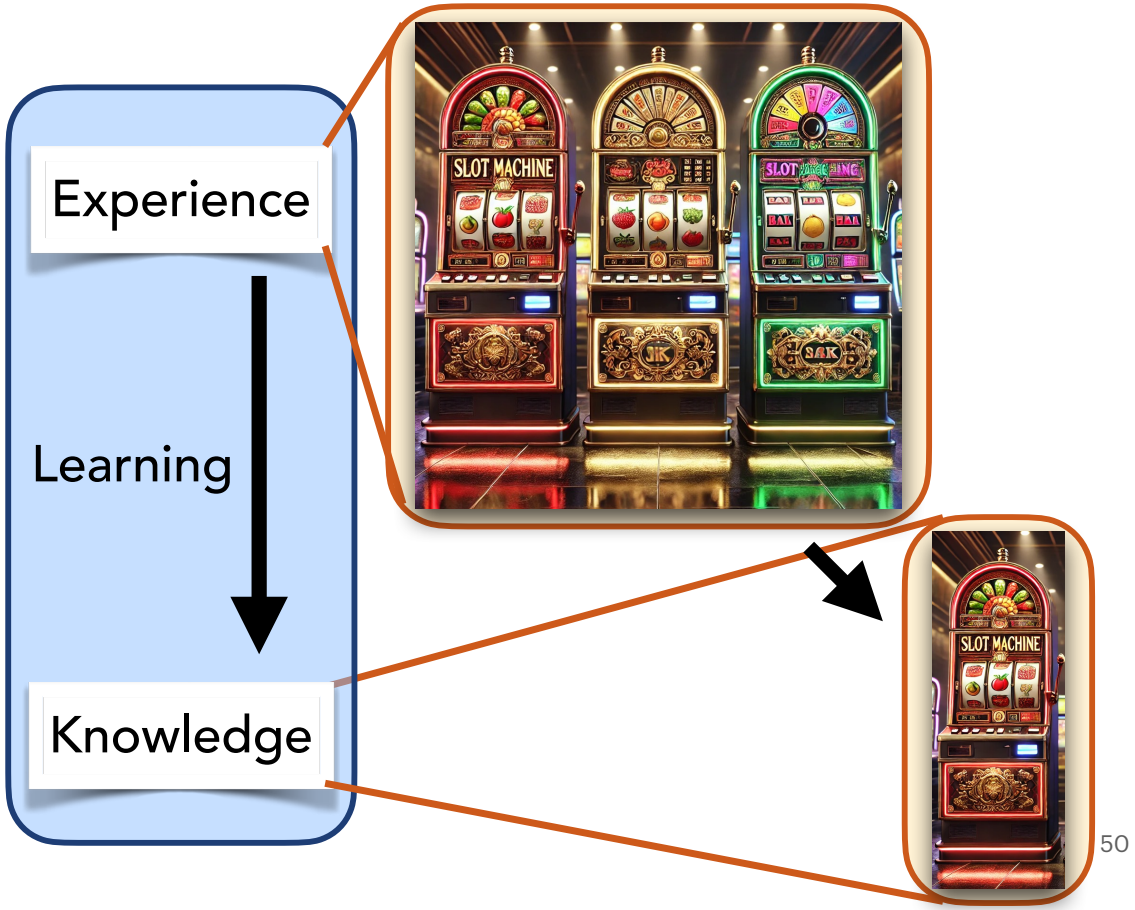

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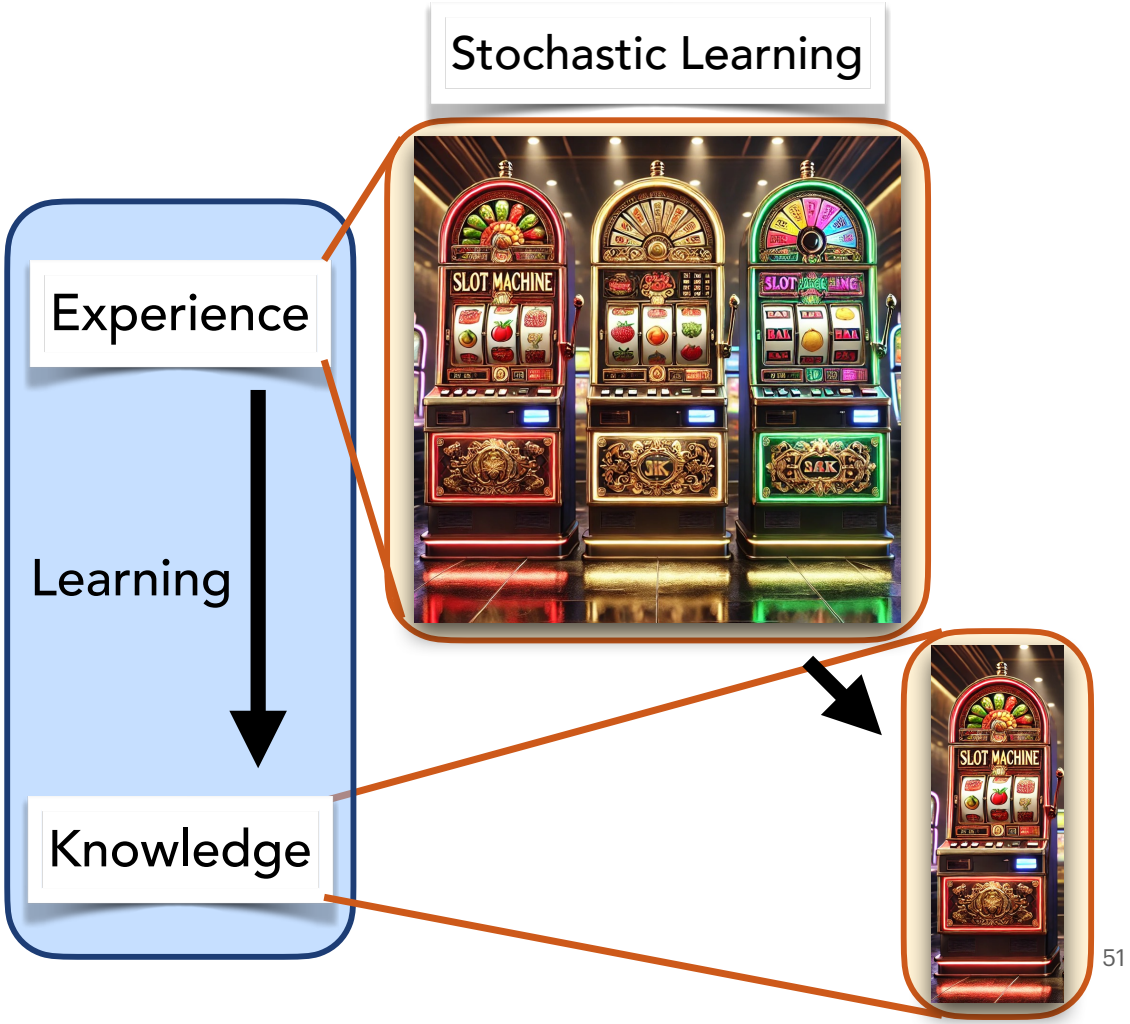

Example: Games

Stochastic Learning

Experience

Learning

Knowledge

Example: Games

Stochastic Learning

Experience

Learning

Knowledge

Example: Games

Stochastic Learning

Adversarial Learning

Experience

Learning

Knowledge

Different Kinds of Learning

Unsupervised Learning

Supervised Learning

Reinforcement Learning

Offline (Batch) Learning

Online Learning

Stochastic Learning

Adversarial Learning

What we Will Cover

Unsupervised Learning

Supervised Learning

Reinforcement Learning

Offline (Batch) Learning

Online Learning

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Adversarial Learning

Supervised, Offline, Stochastic Learning

What we Will Cover

Unsupervised Learning

Supervised Learning

Reinforcement Learning

Offline (Batch) Learning

Online Learning

Stochastic Learning

Adversarial Learning

Supervised Learning = Supervised, Offline, Stochastic Learning

What we Will Cover

Unsupervised Learning

Supervised Learning

Reinforcement Learning

Offline (Batch) Learning

Online Learning

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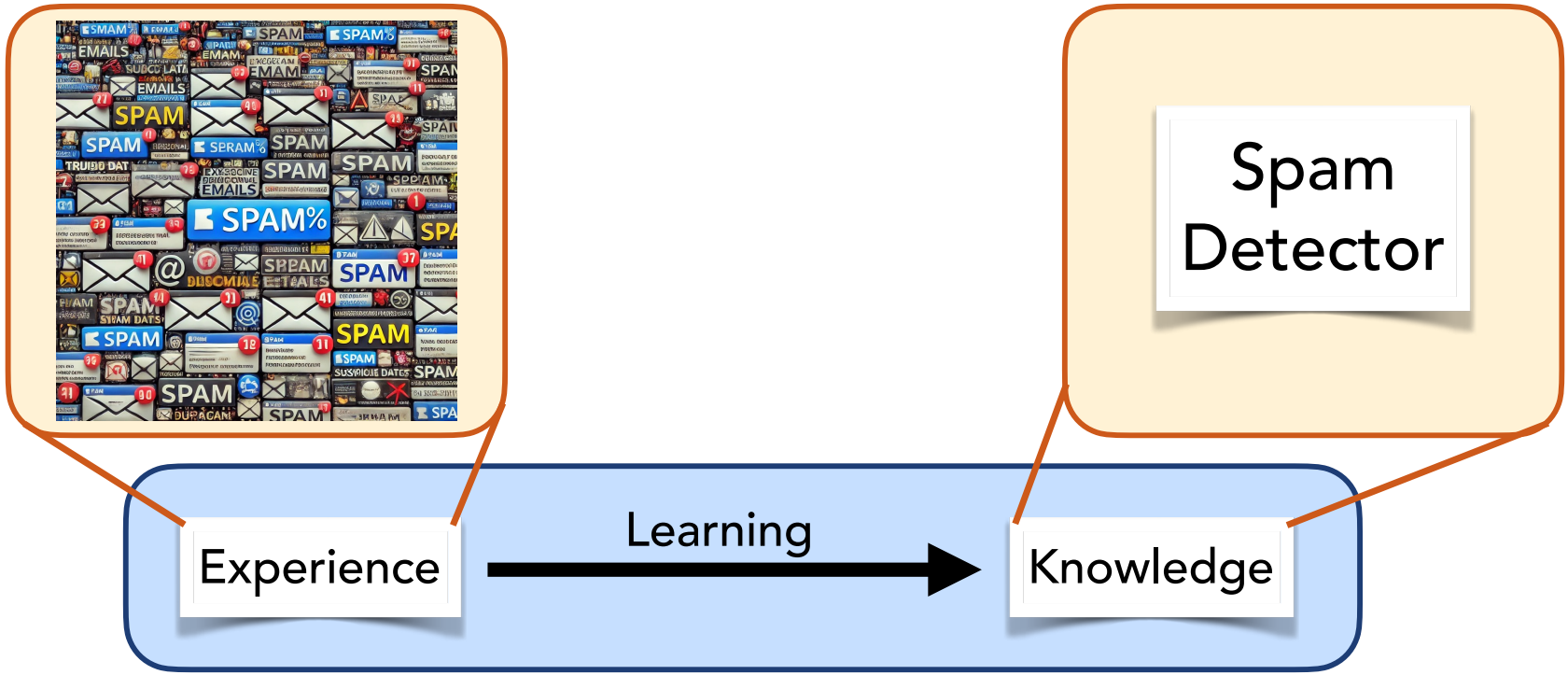
Adversarial Learning

Supervised Learning = Learning from a **batch** of **labeled** randomly **selected** experience

Example: Spam Detector



Supervised Learning = Learning from a **batch** of **labeled** randomly **selected** experience

Why are machines (programs) that learn useful?
(instead of just having humans)

Why are Programs Useful?

Programs can perform computations much more efficiently than humans

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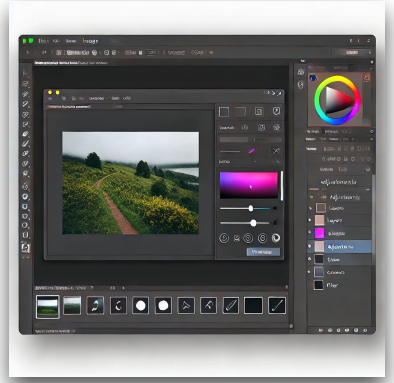

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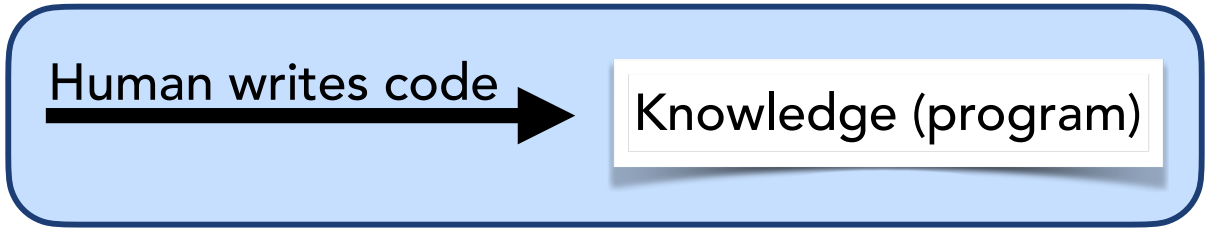
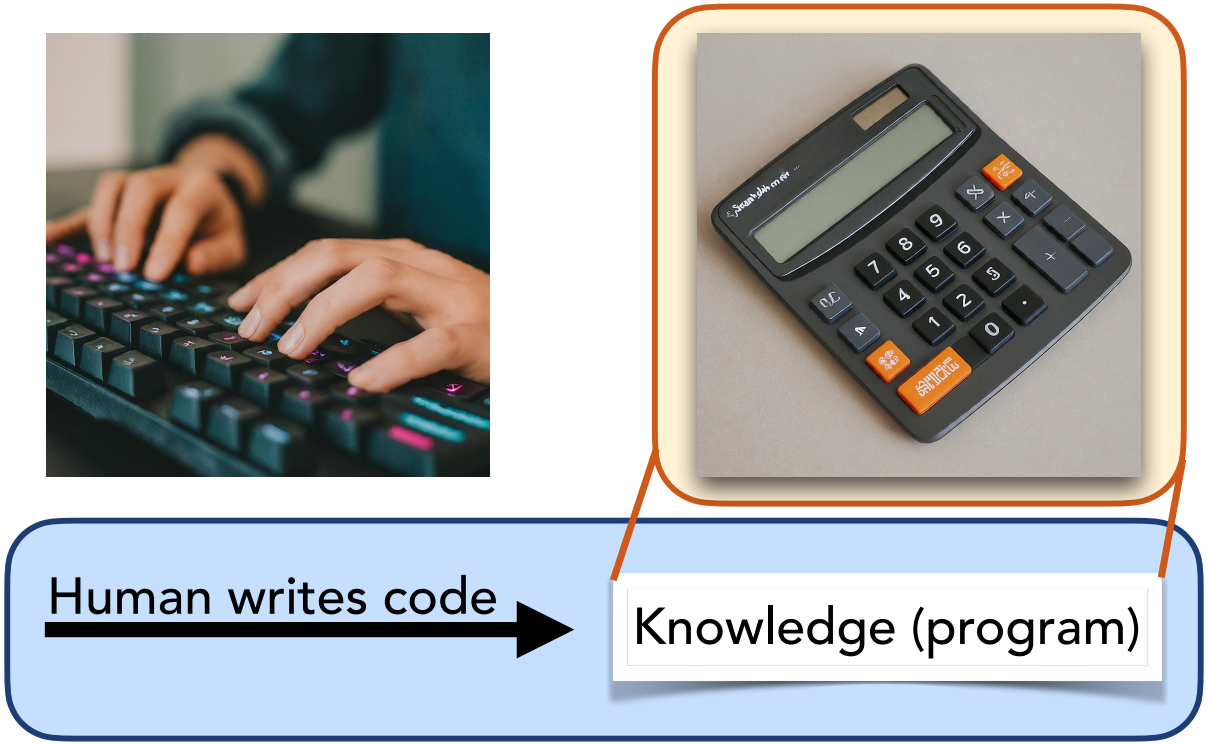
- etc.

Classic Programs

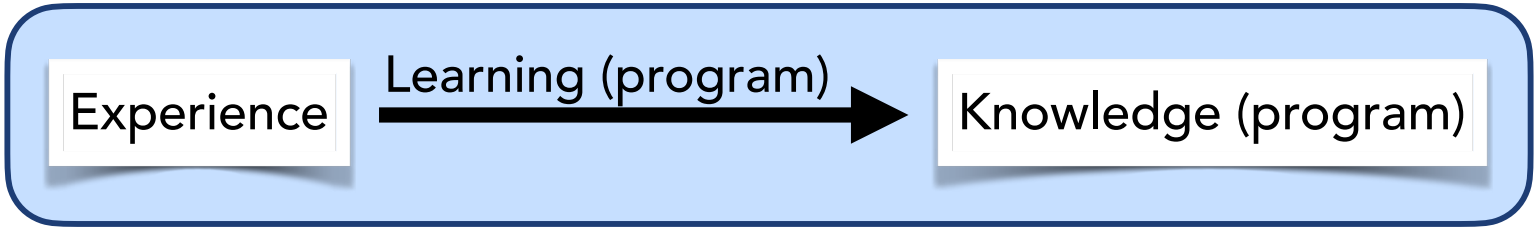


Classic Programs

Example: A human writes a calculator program.

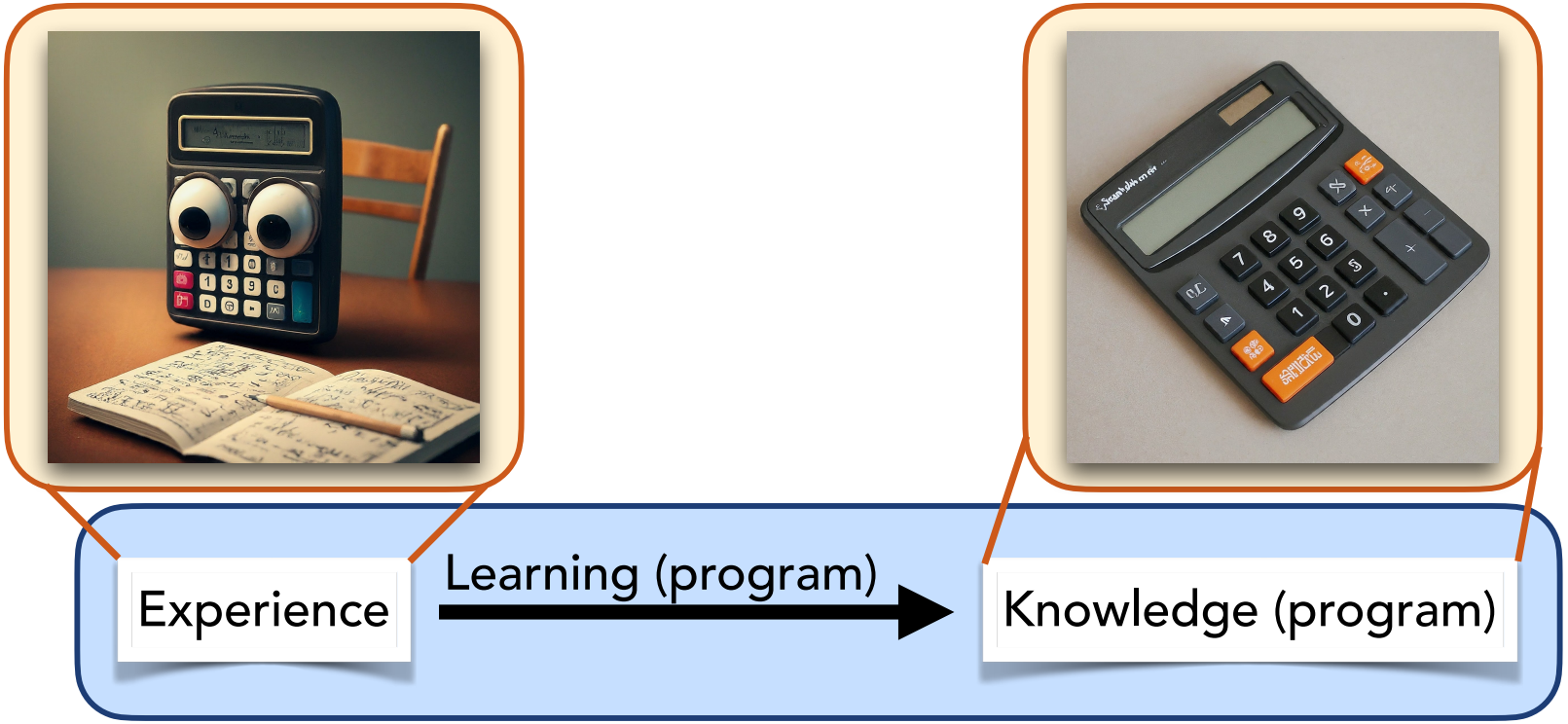


Programs that Learn



Programs that Learn

Example: A calculator learns addition by seeing examples of numbers being added together.



Why are Programs that Learn Useful?

1. We don't know how to write the code for certain types of knowledge

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   Examples:

   - Creating an image of something

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   Examples:

   - Creating an image of something

     "Generate an image of a cat"

Why are Programs that Learn Useful?

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   Examples:

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     "Generate an image of a person that can not explain the steps to draw a cat"

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     "Generate an image of a person that can not explain the steps to draw a cat"

All of the images in this presentation were generated by

hat Learn Useful?

1. 

."

- Object detection: stop sign, pedestrian, red light, green light, etc.

Why are Programs that Learn Useful?

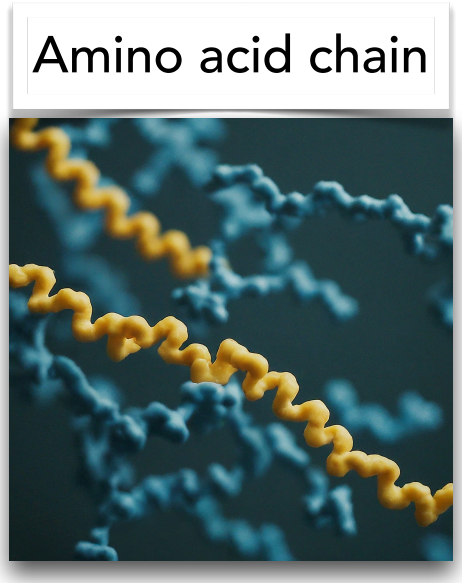
More examples:

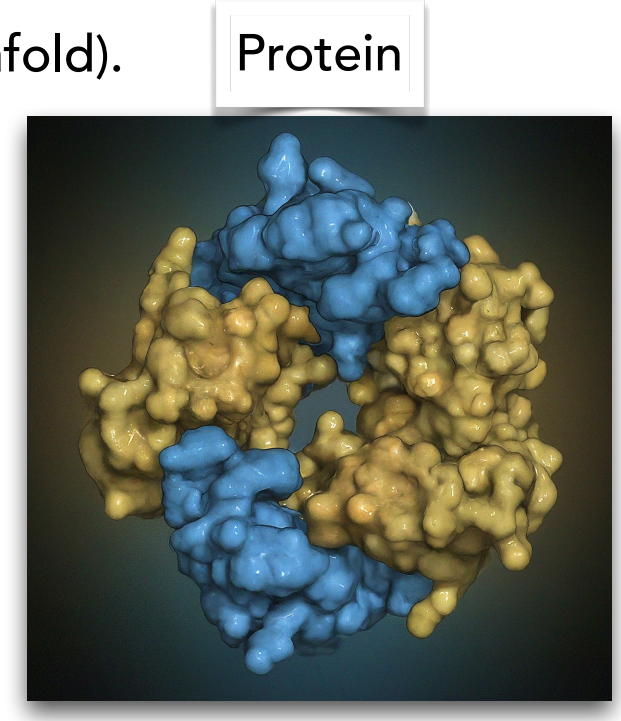
- Chatbot (LLMs: ChatGPT, Claude, Gemini, etc.)

Why are Programs that Learn Useful?

More examples:

- Chatbot (LLMs: ChatGPT, Claude, Gemini, etc.)
- Discovery: Predicting protein folding (Deepmind's Alphafold).





Why are Programs that Learn Useful?

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Why are Programs that Learn Useful?

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   Example:

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Day time

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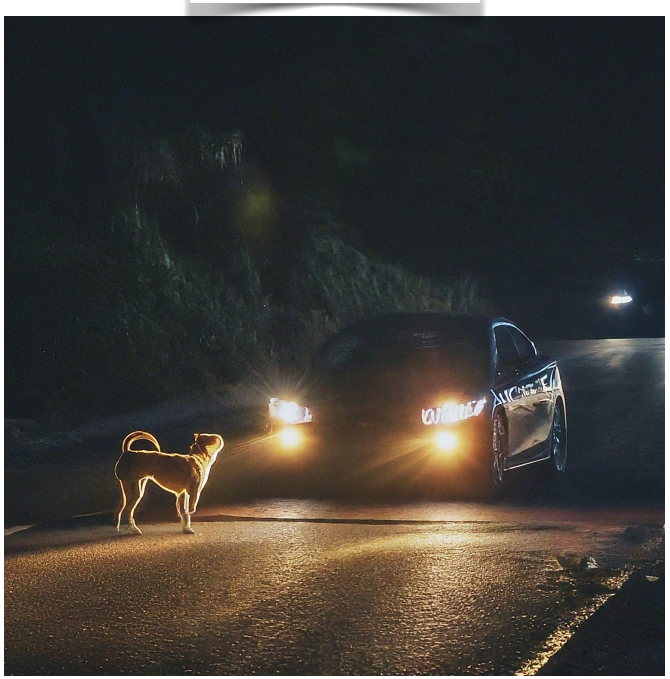


What will you learn in this course?

What we Will Cover

Unsupervised Learning

Supervised Learning

Reinforcement Learning

Offline (Batch) Learning

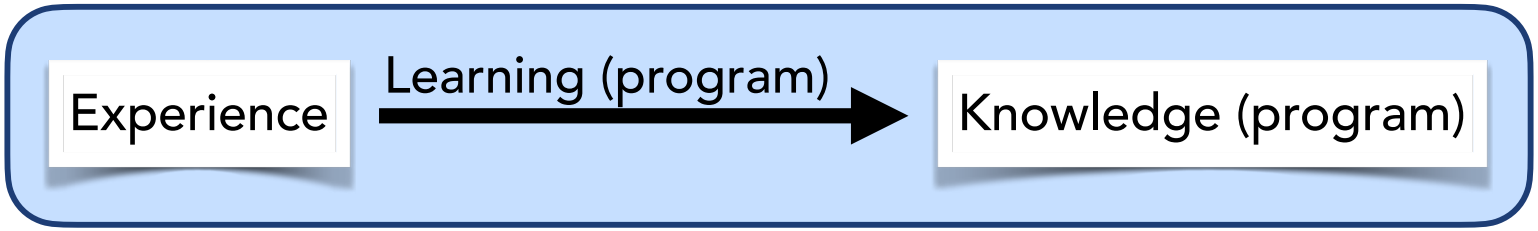
Online Learning

Stochastic Learning

Adversarial Learning

Supervised Learning = Learning from a batch of labeled randomly selected experience

You will learn to write a program that learns



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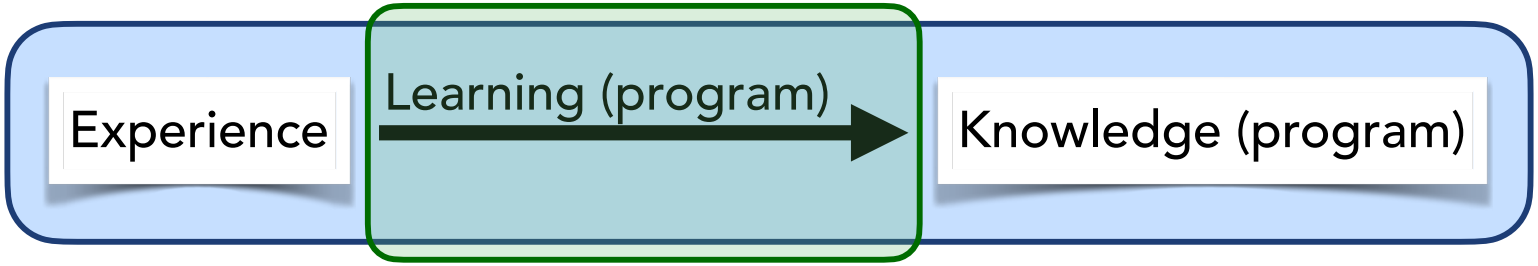

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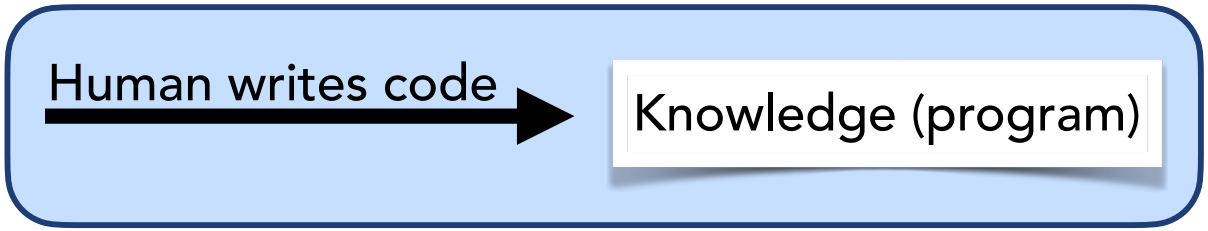

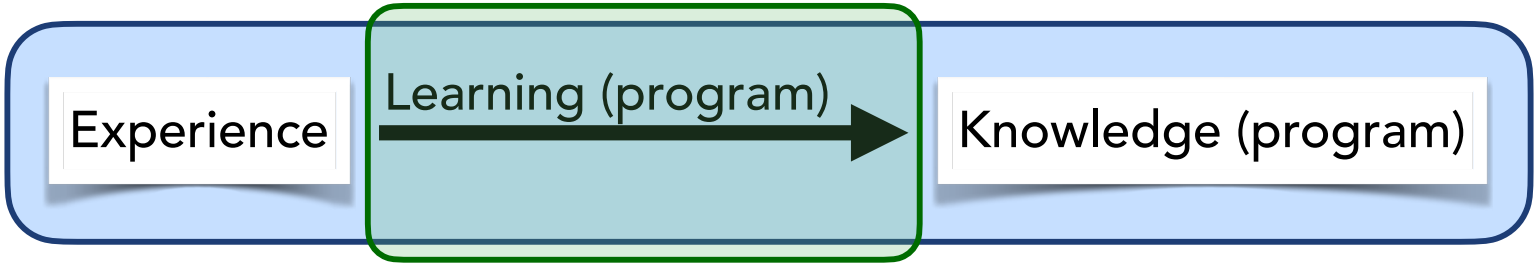

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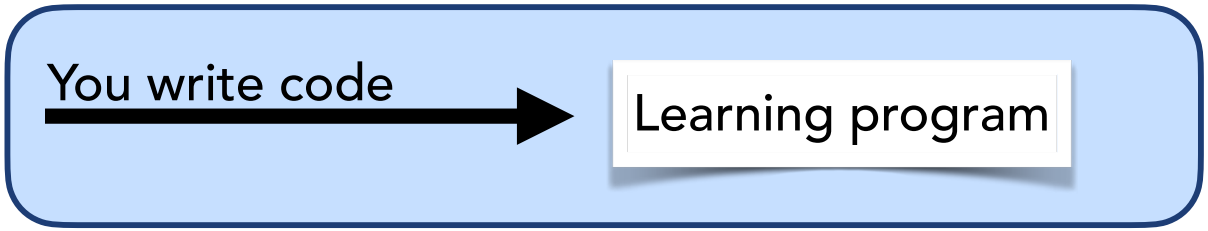

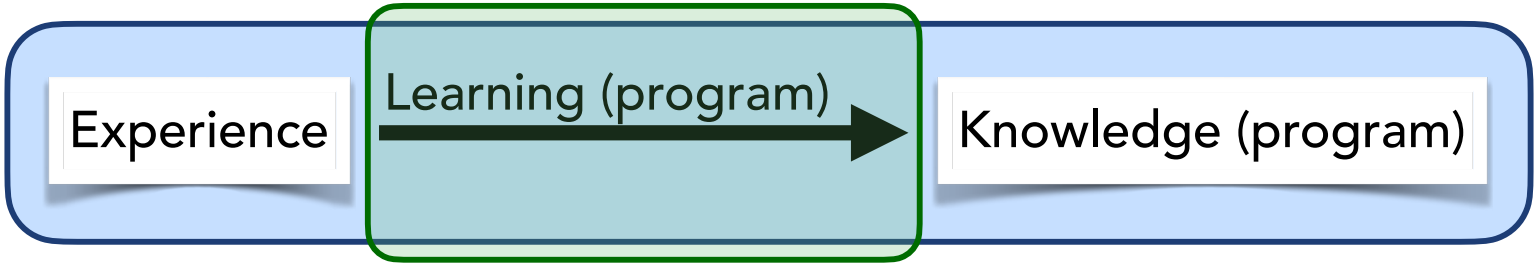

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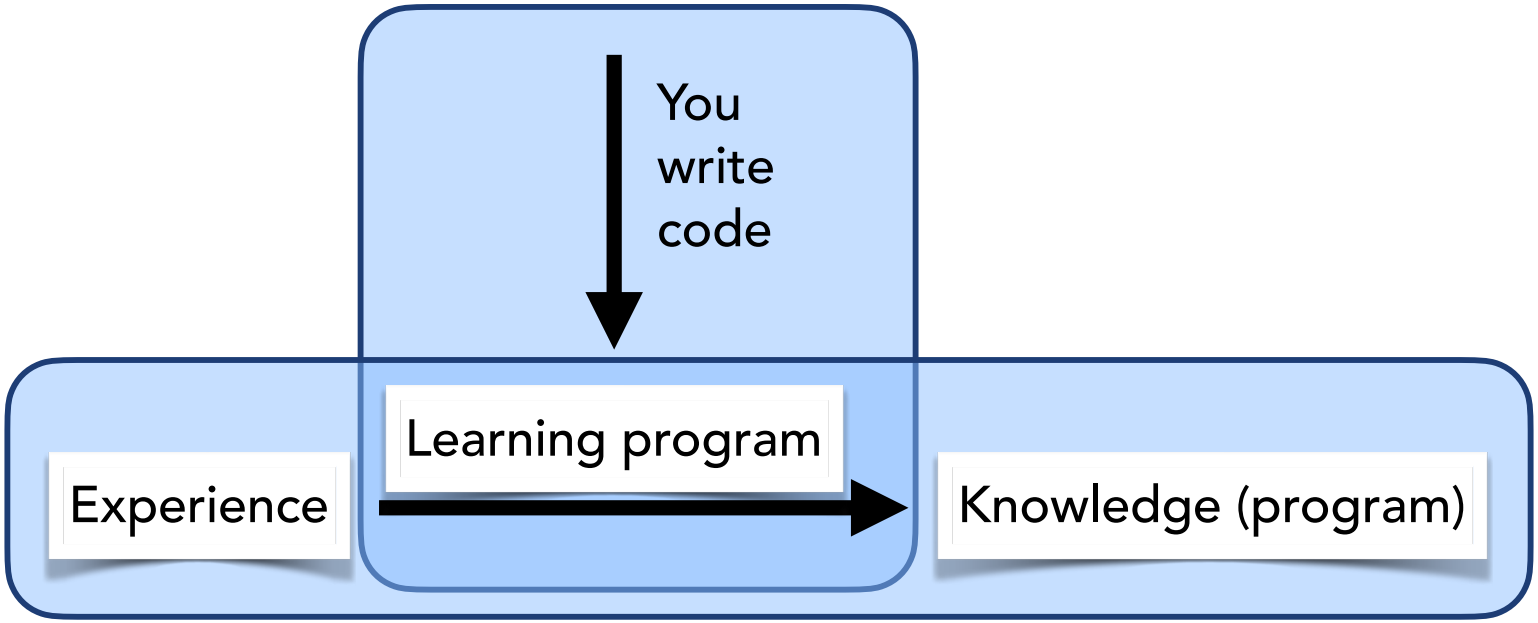

Examples of what that looks like

Example: Predicting House Prices Based on # of Rooms

# Of Rooms	Price
2	$200k
4	$590k
3	$350k
7	$970k

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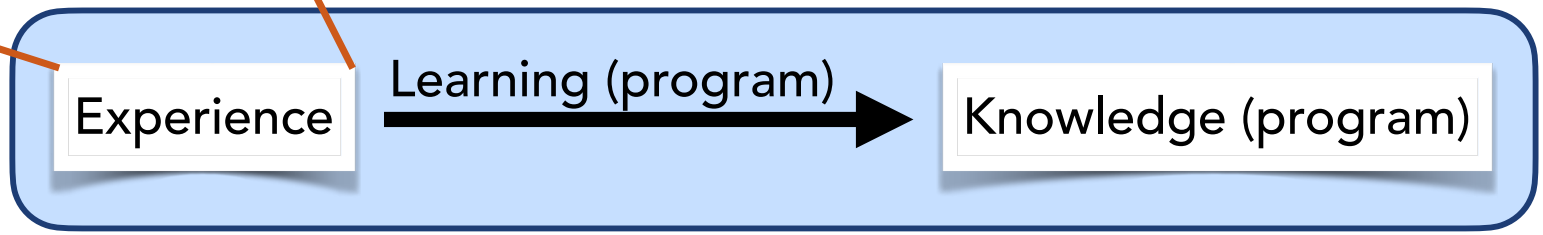

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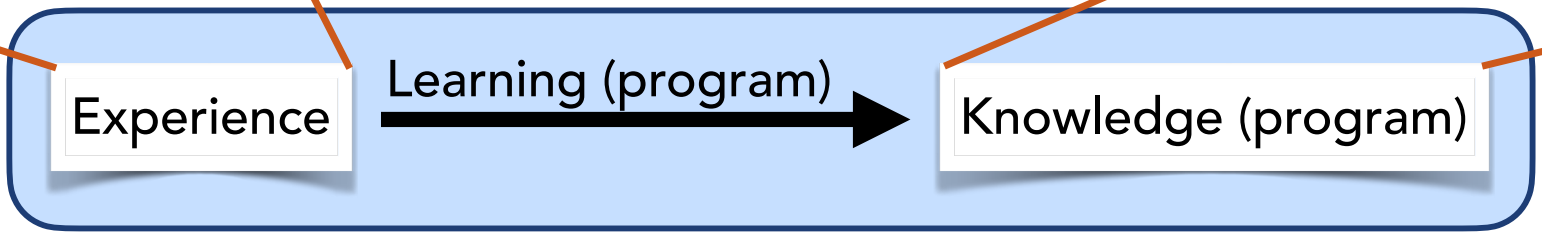

Prediction function f :

Input: # of rooms

Output: price

Example: $f(5) = \$700k$

Example: Predicting House Prices Based on # of Rooms

# Of Rooms	Price
2	$200k
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Objective:

Write a Learning program that outputs a predictor f,

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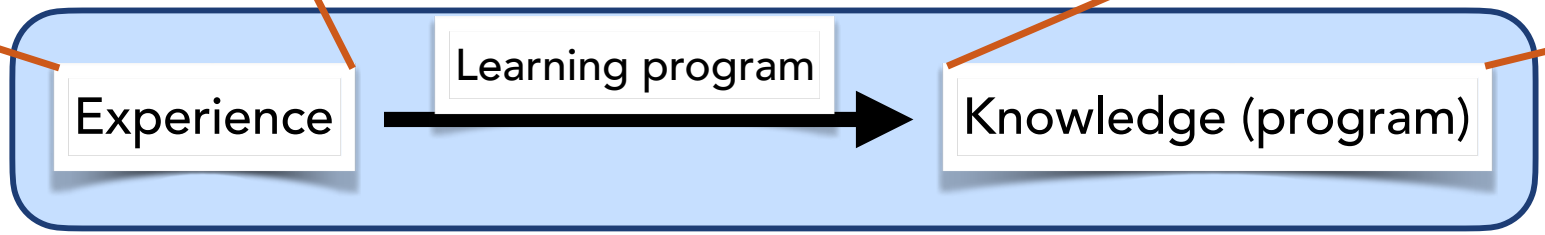

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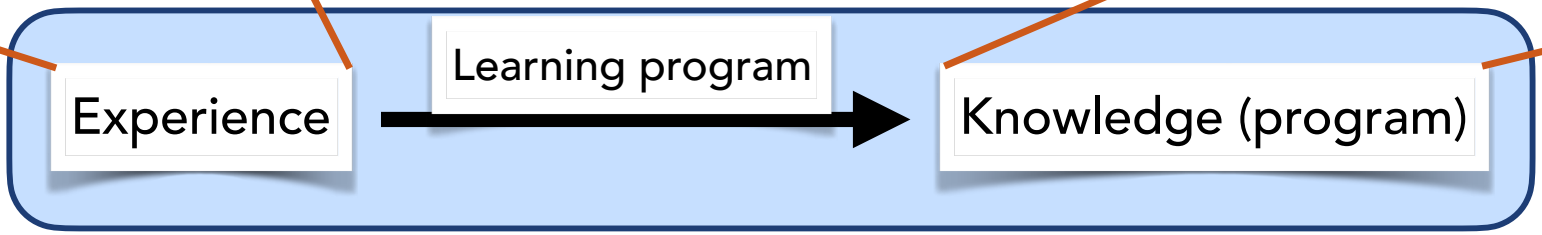

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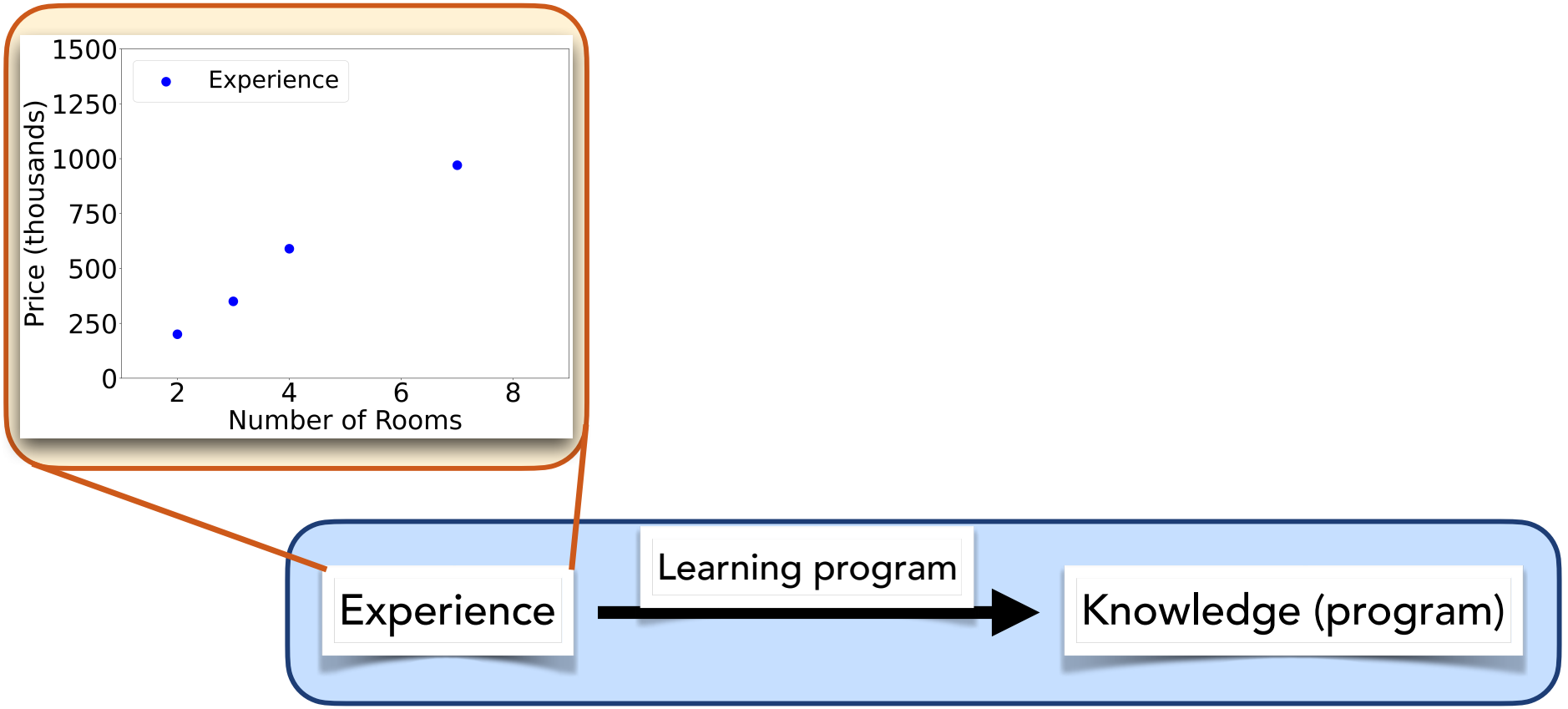

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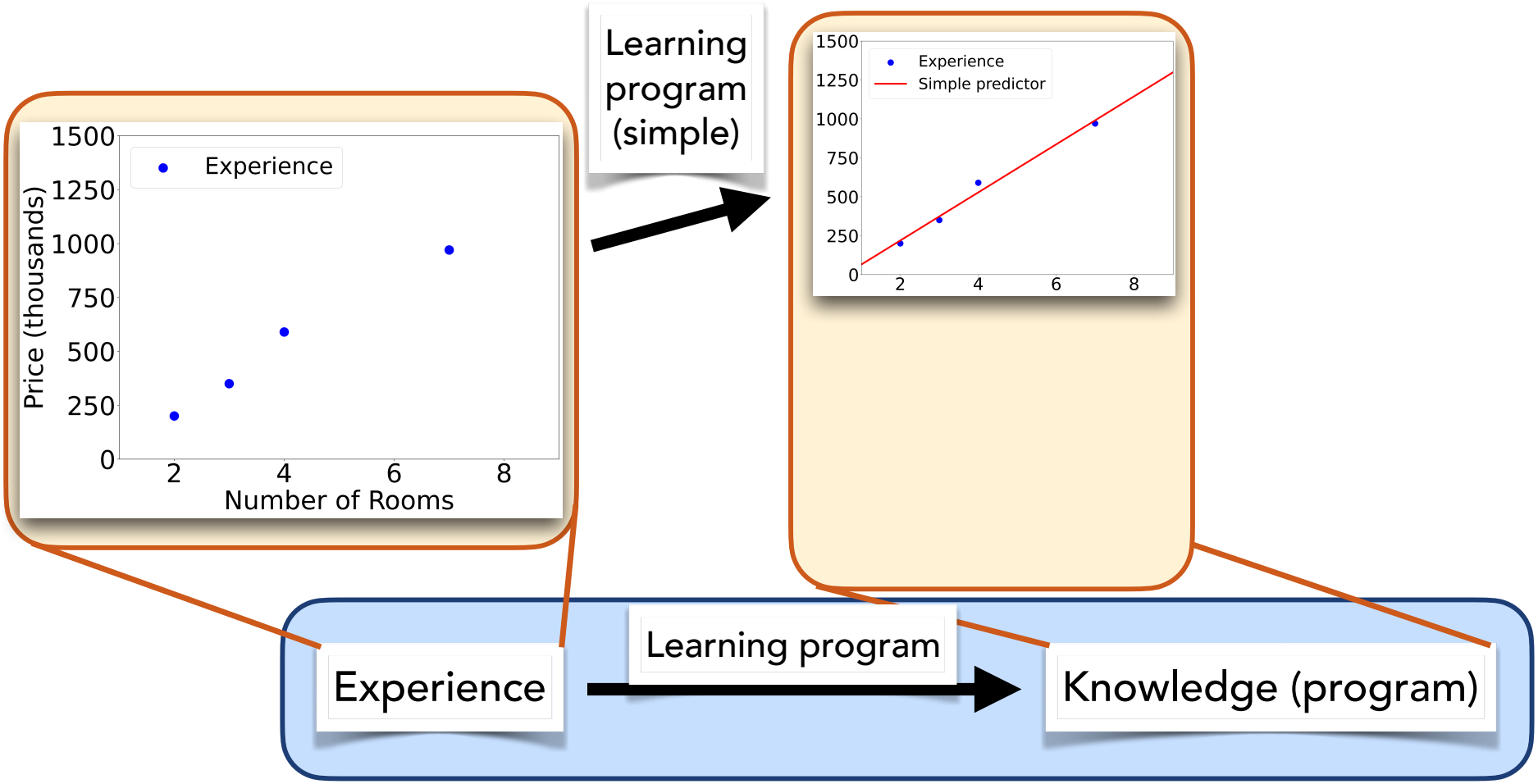

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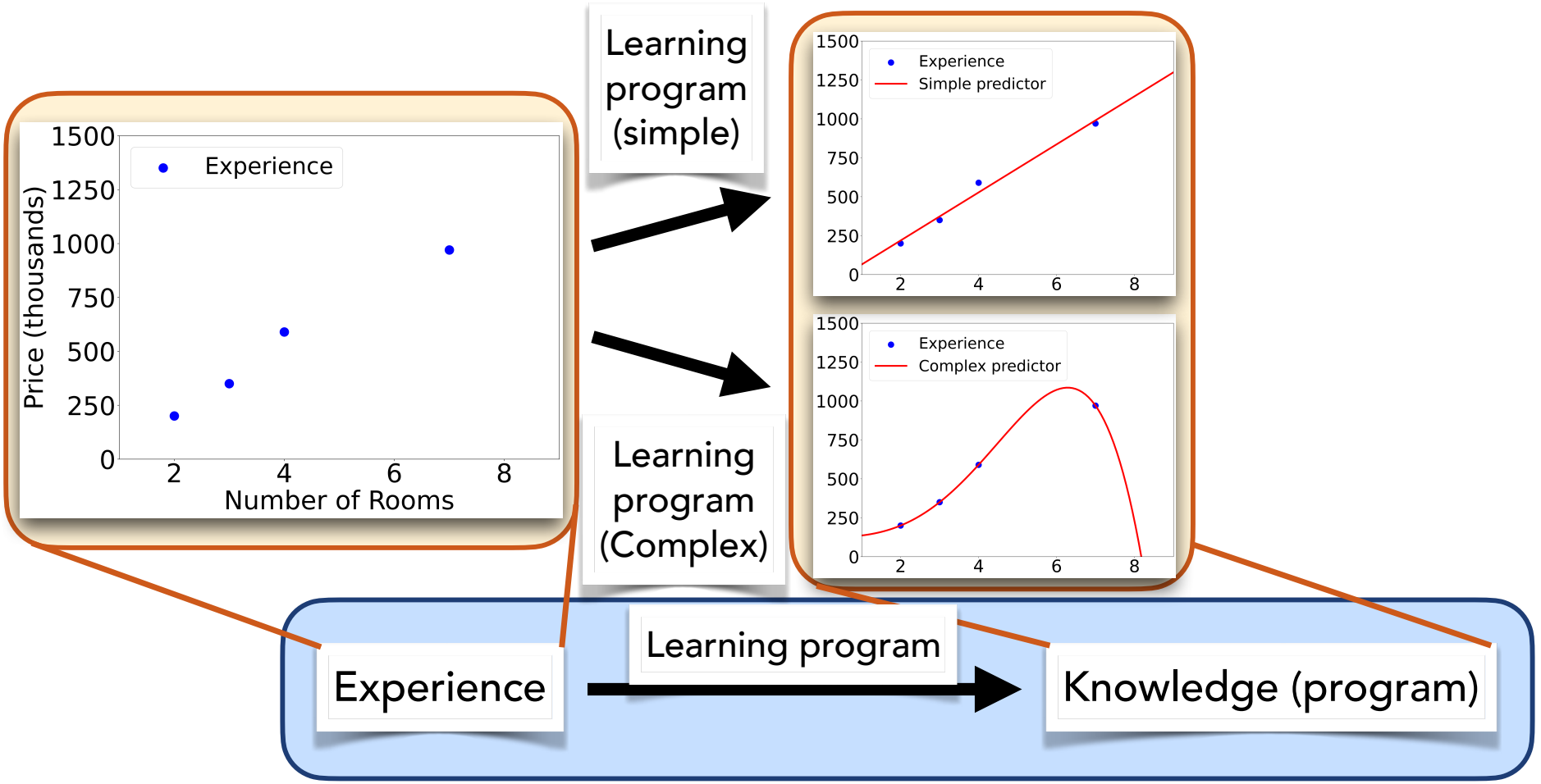

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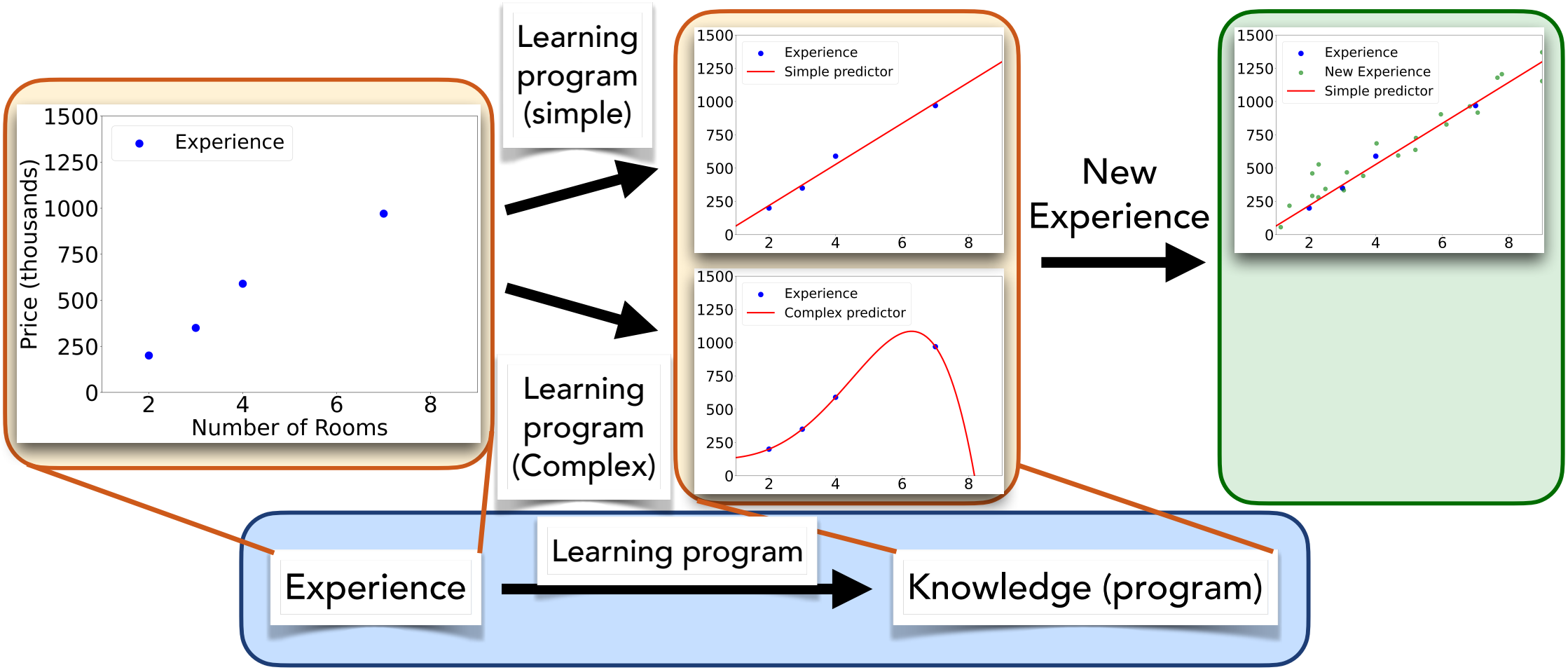

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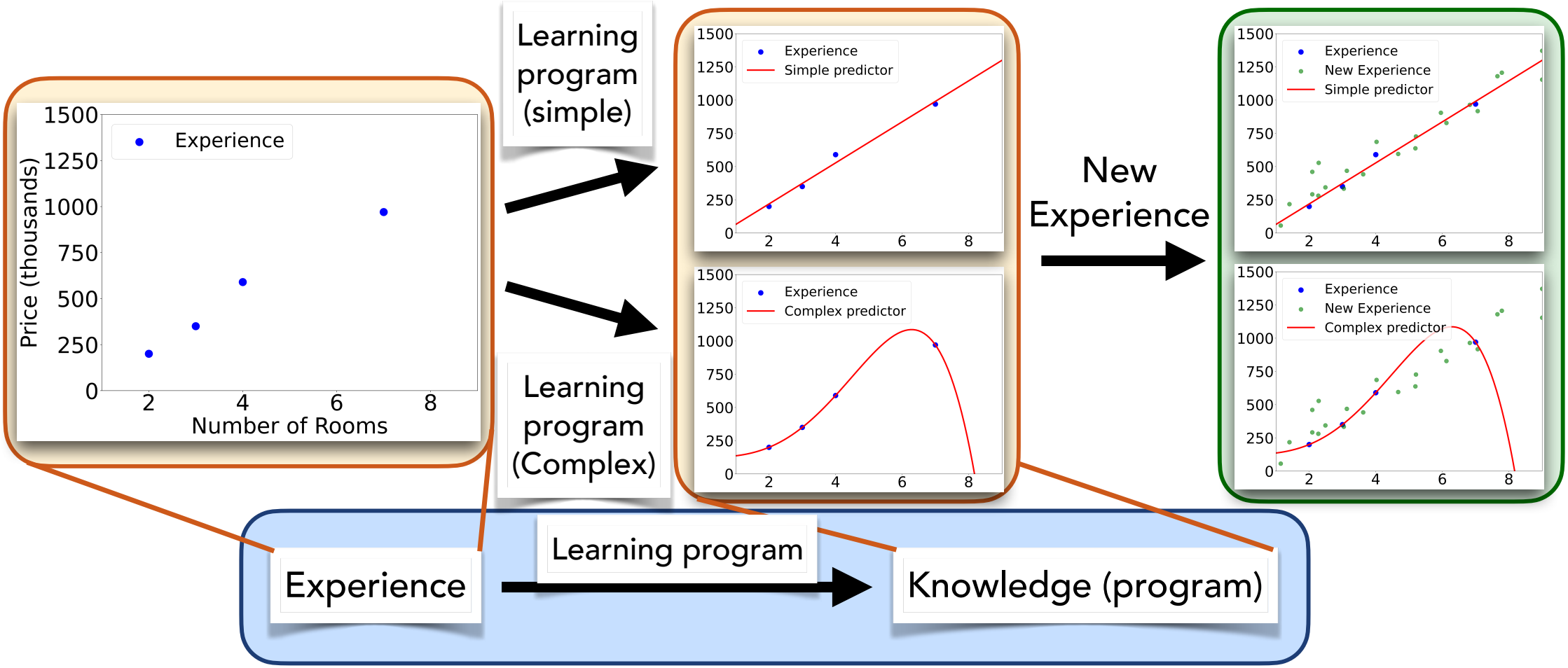
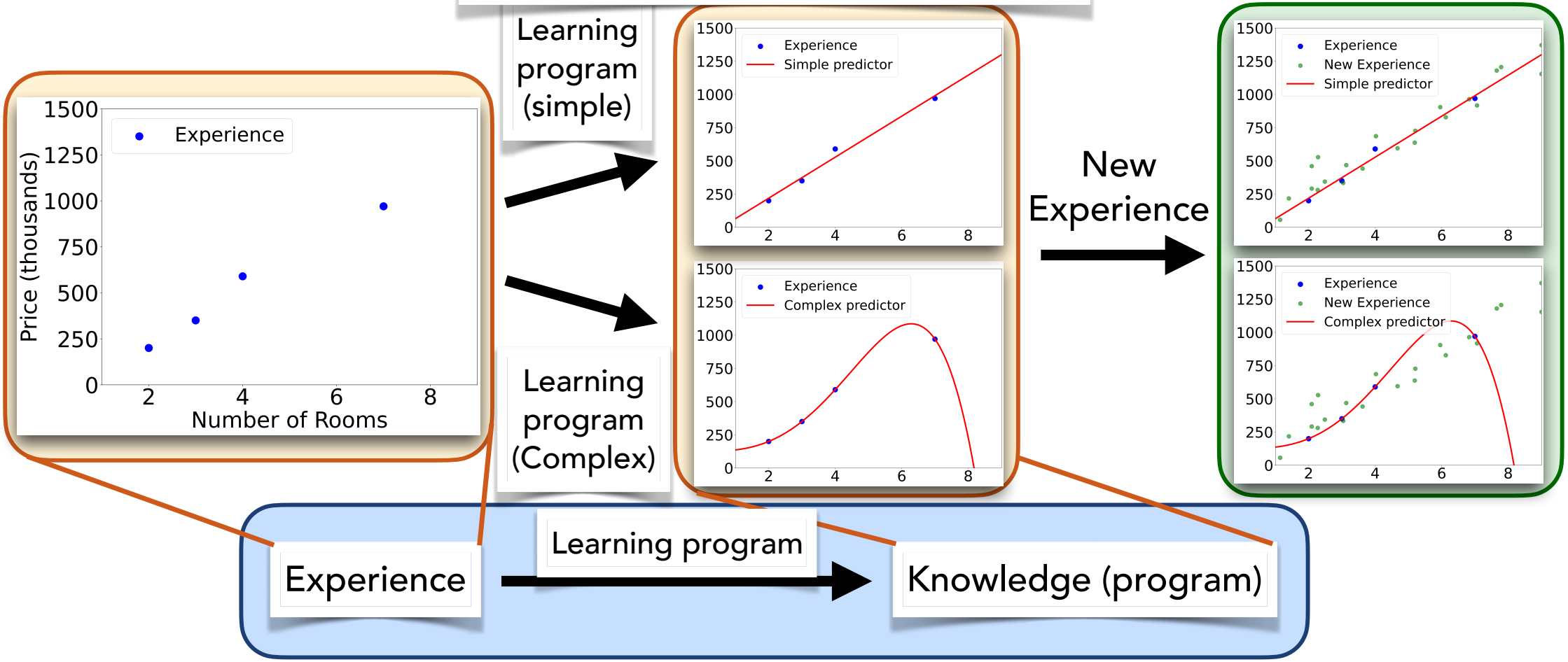


Example: Pred … on # of Rooms

Complex predictor is a Neural Network



Example: Classifying Wine Based on Chemical Properties

Proline	Flavanoid	Type
2.3	3.4	Barolo
1.6	0.8	Not Barolo
⋮	⋮	⋮
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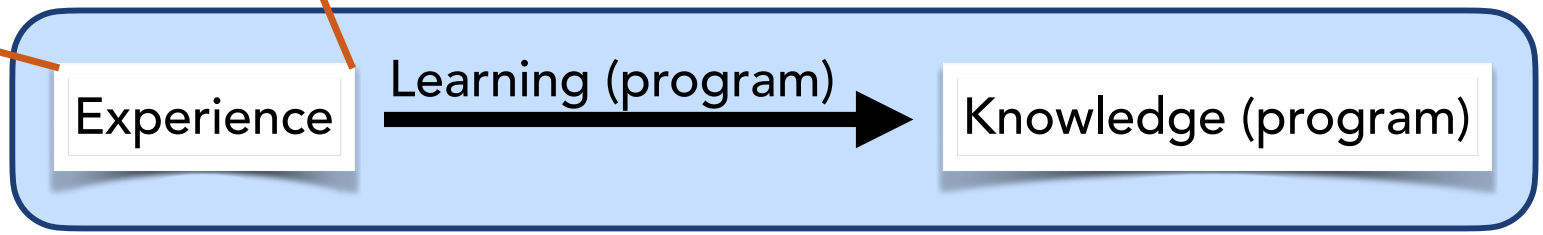

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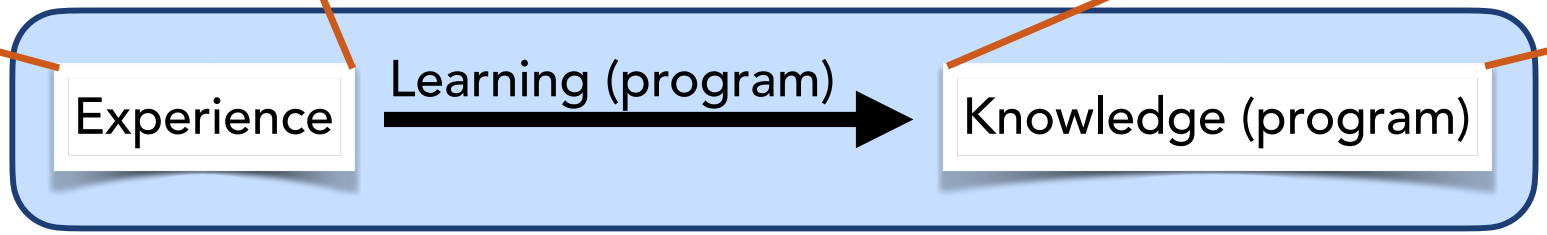
Example: $f(3,3) =$ Barolo



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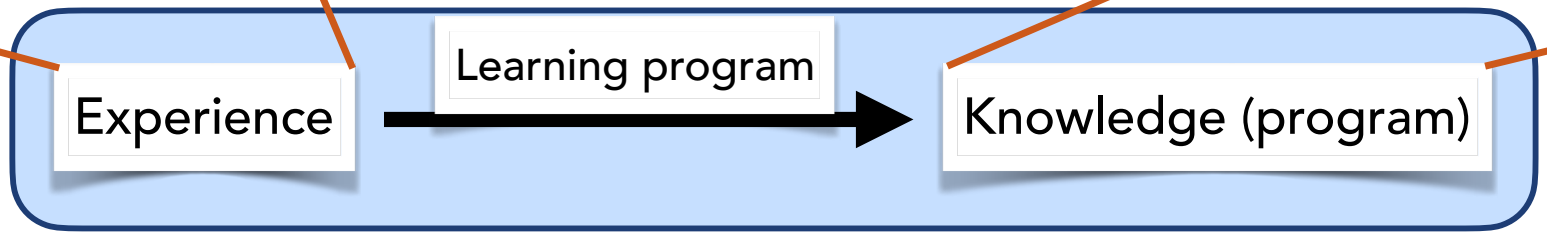

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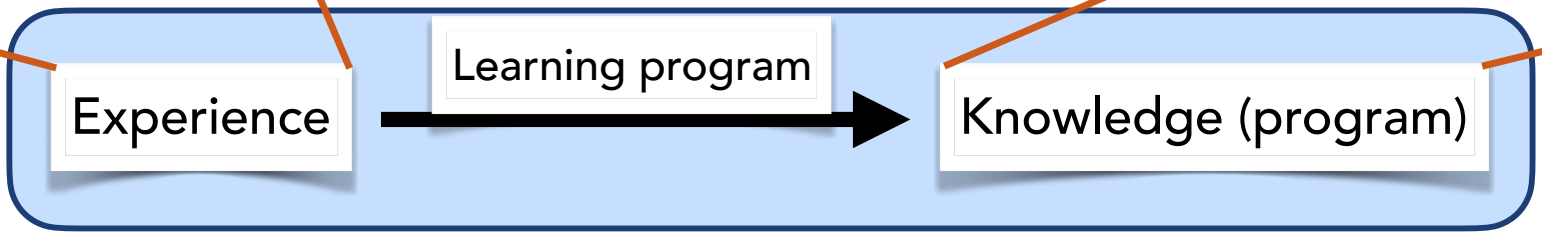

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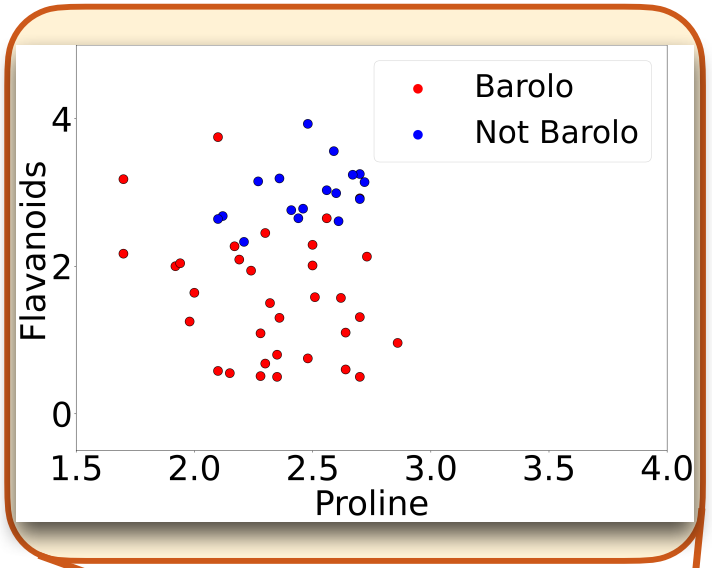

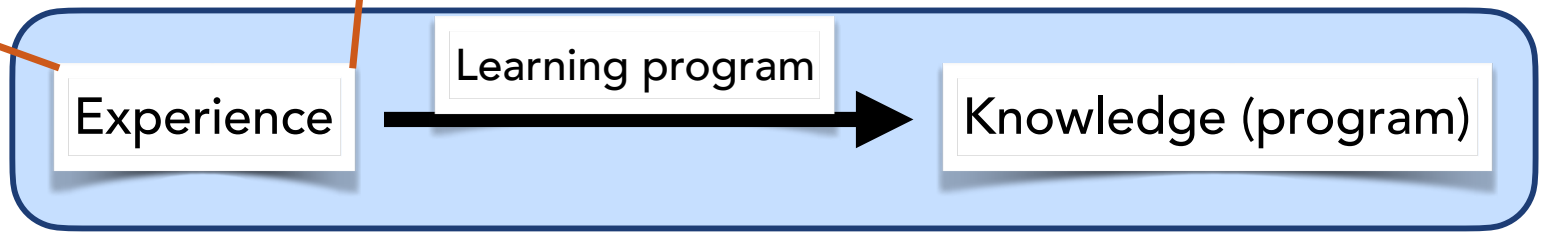

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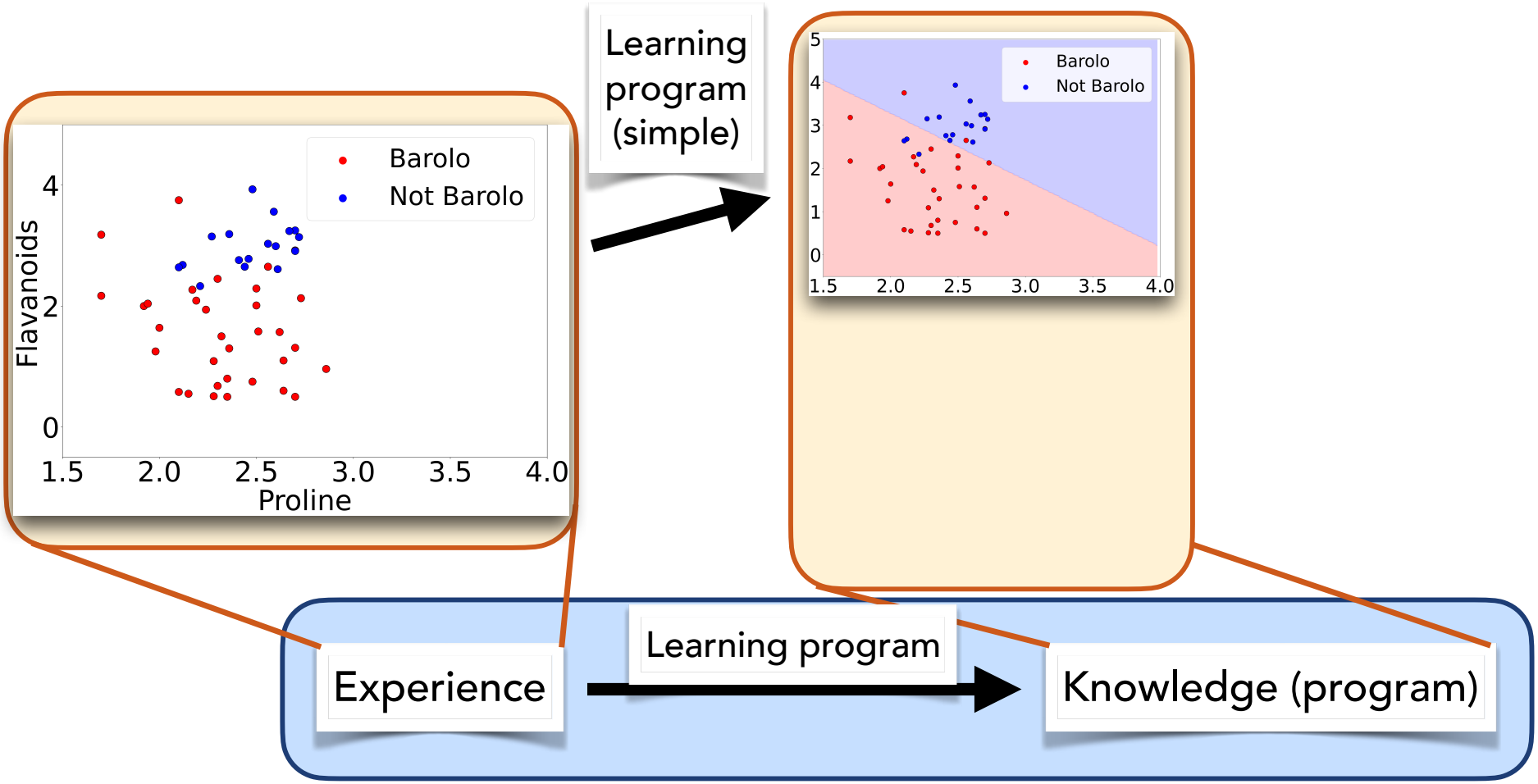

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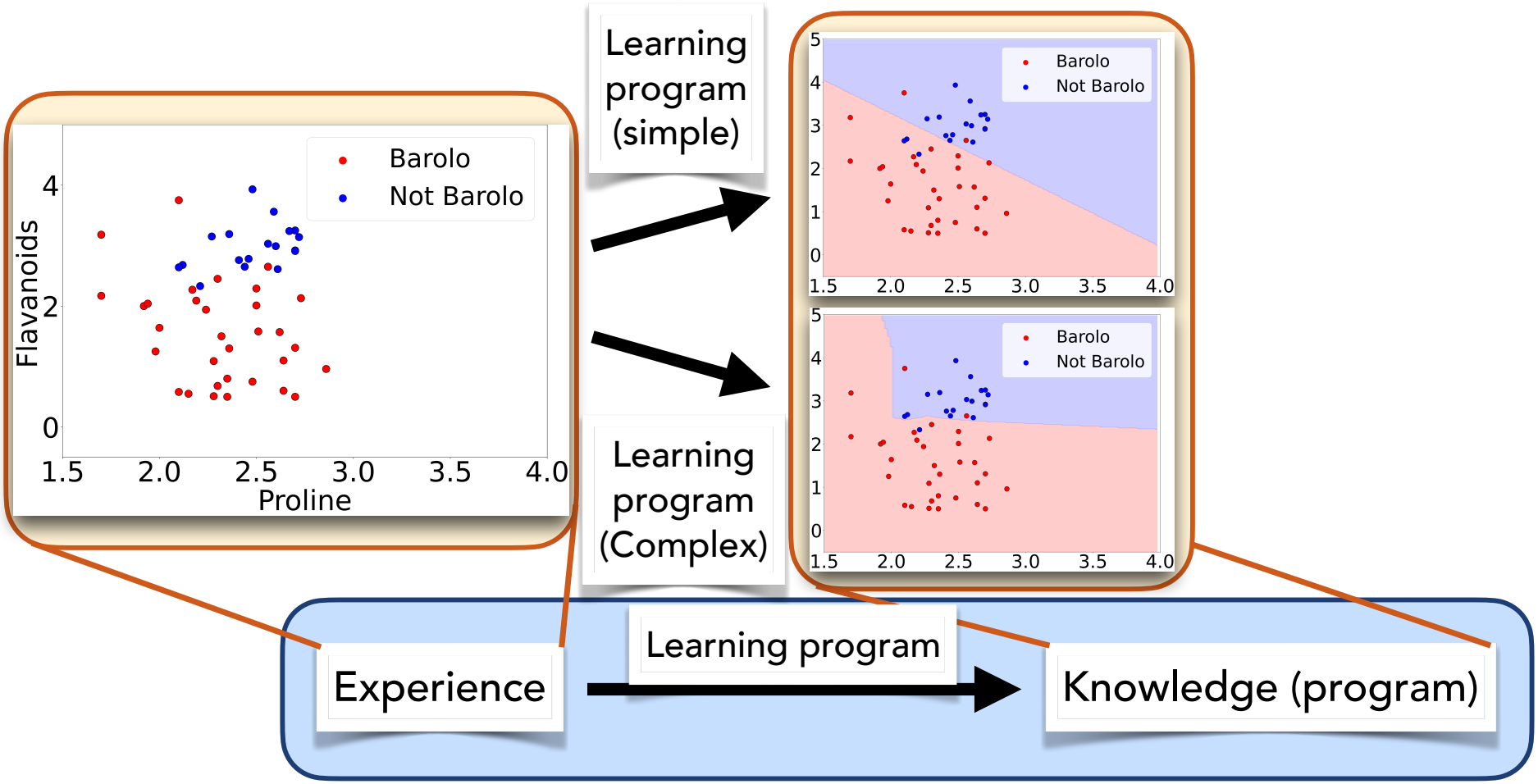

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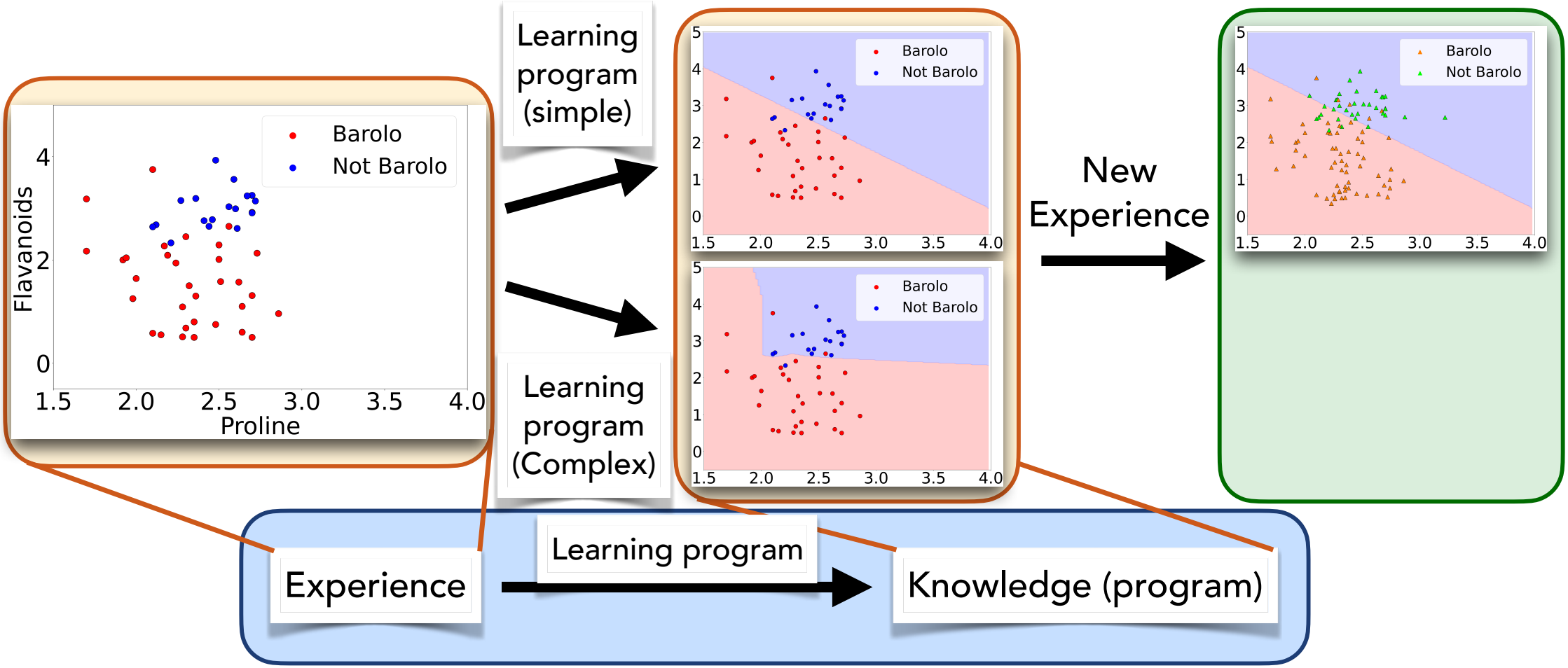

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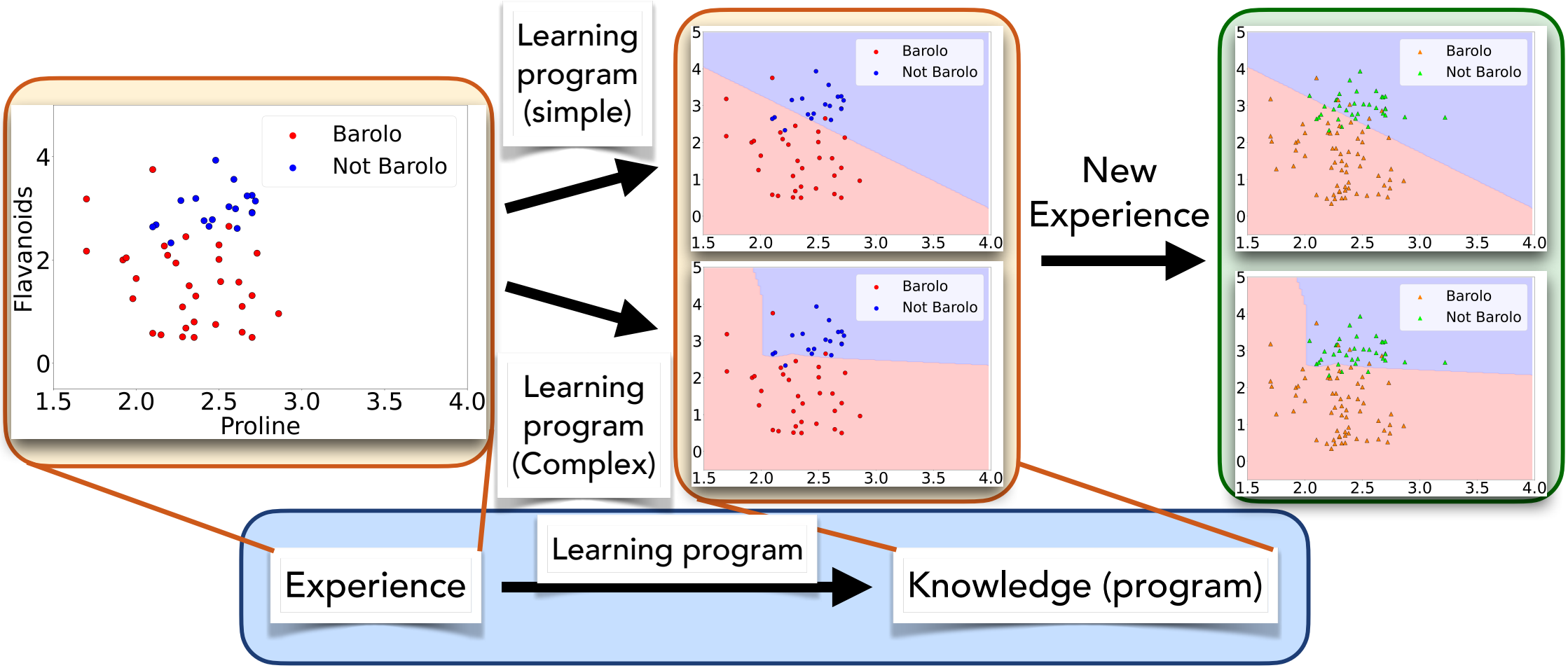


Regression vs Classification

Regression: Labels are continuous values (ex: house prices)

Classification: Labels are discrete and unordered (ex: type of wine)

Course Outline

1. Math and probability review
2. Define supervised learning formally (splitting it into regression or classification)
3. Design some learning programs to solve regression problems

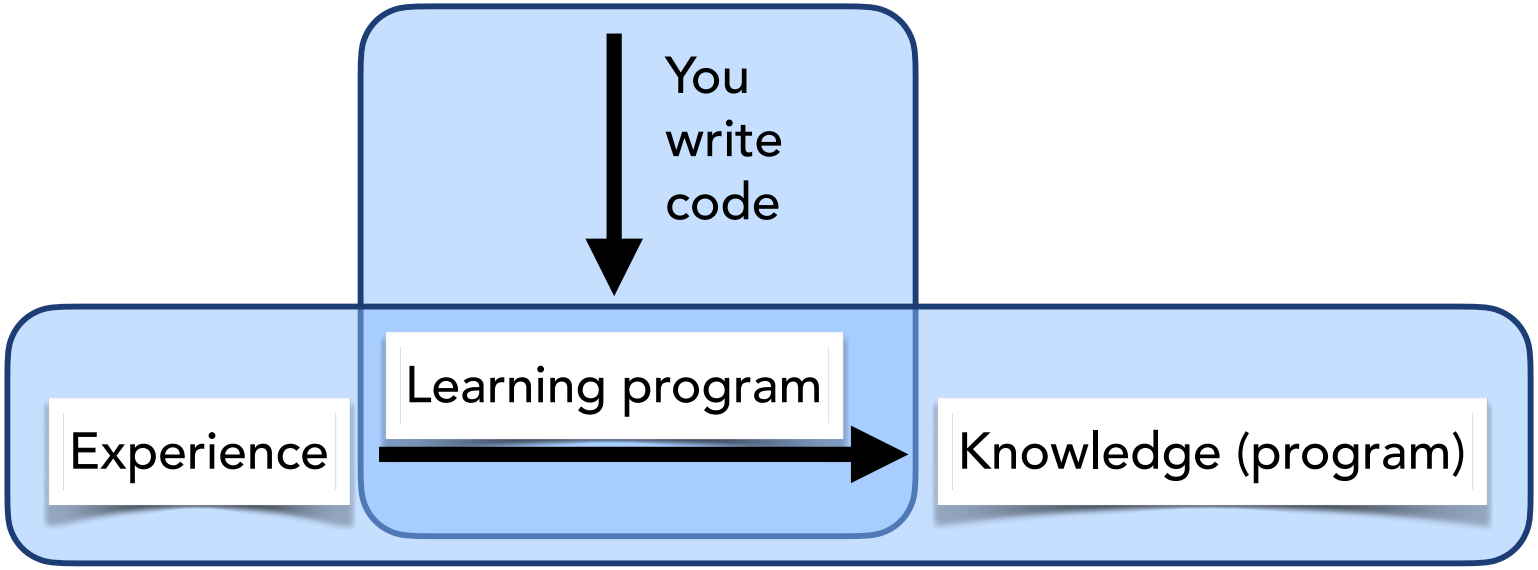
   Midterm Exam 1
4. Evaluate our learning programs
5. Present some new ways to design learning programs for regression

   Midterm Exam 2
6. Repeat the above for classification problems
7. Brief intro to neural networks / large language models

   Final Exam (Cumulative)

The code for all of the plots was generated by

Wait a Minute…



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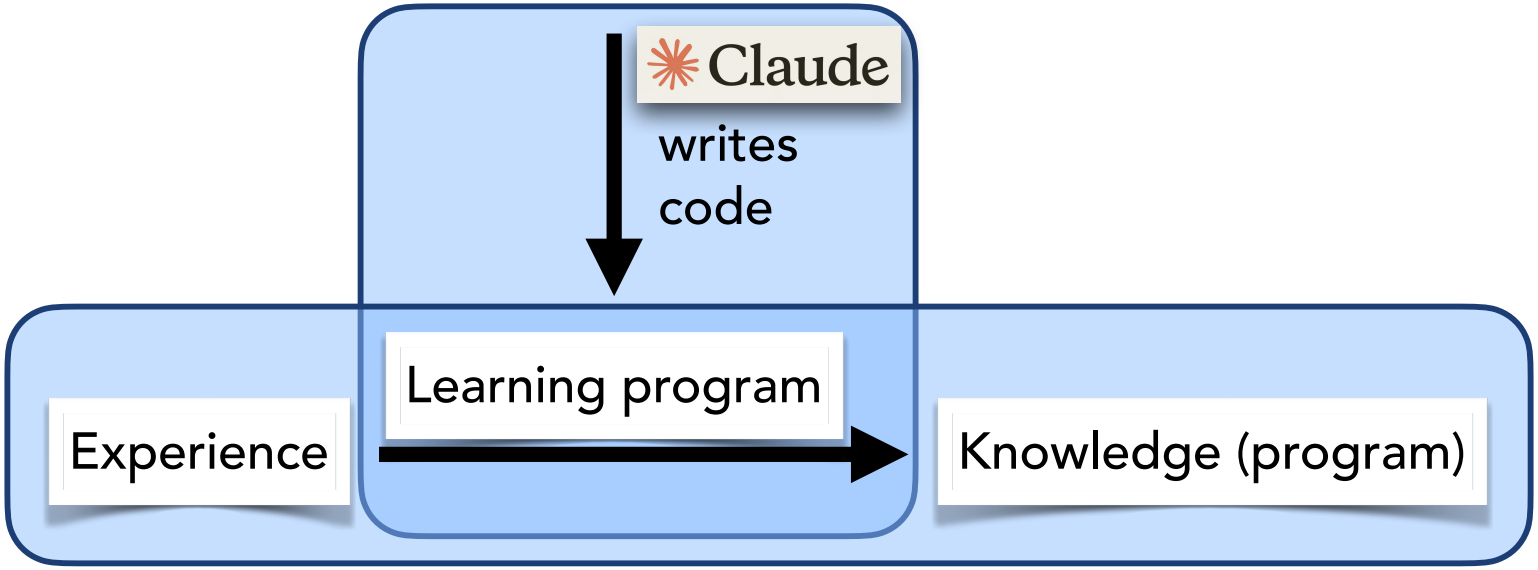

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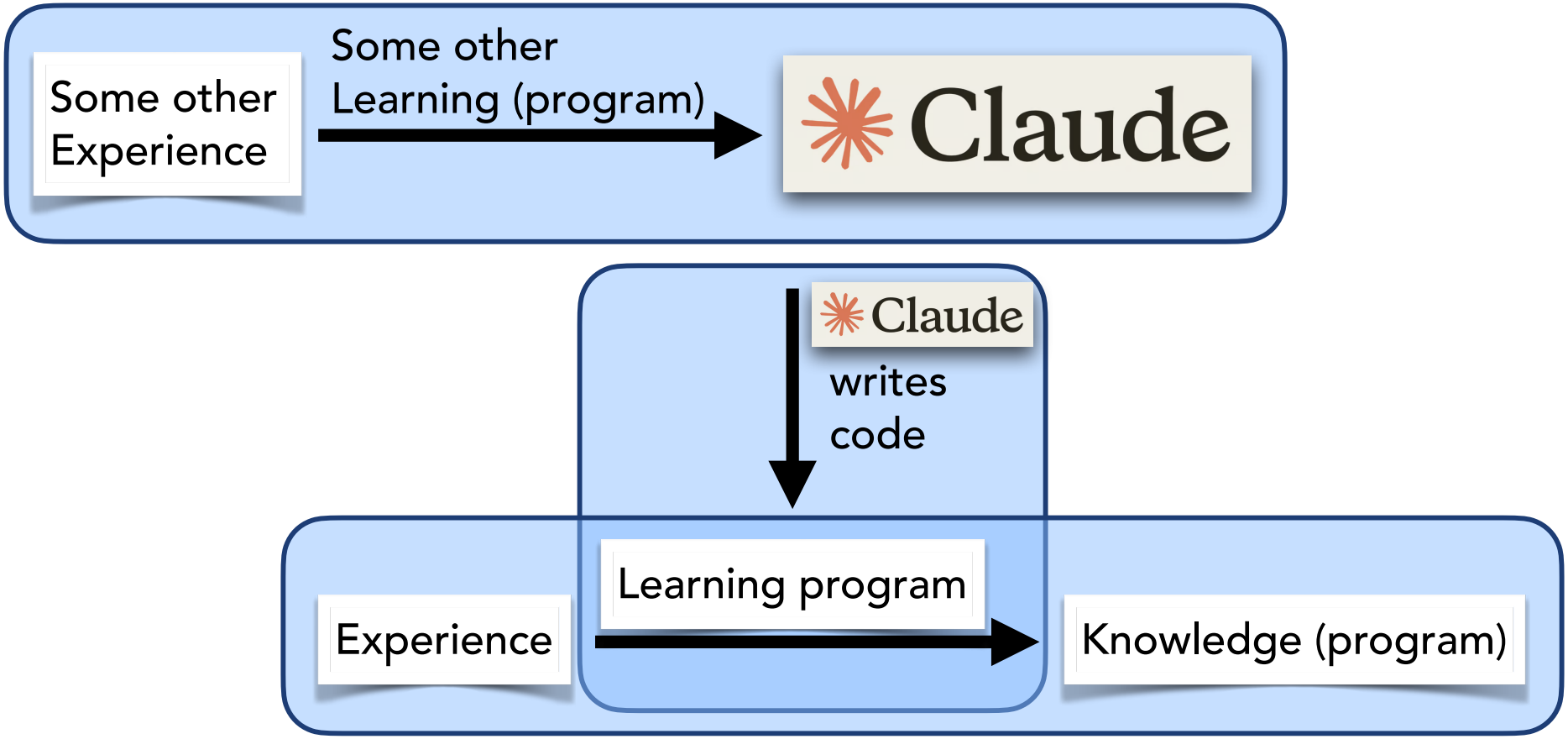

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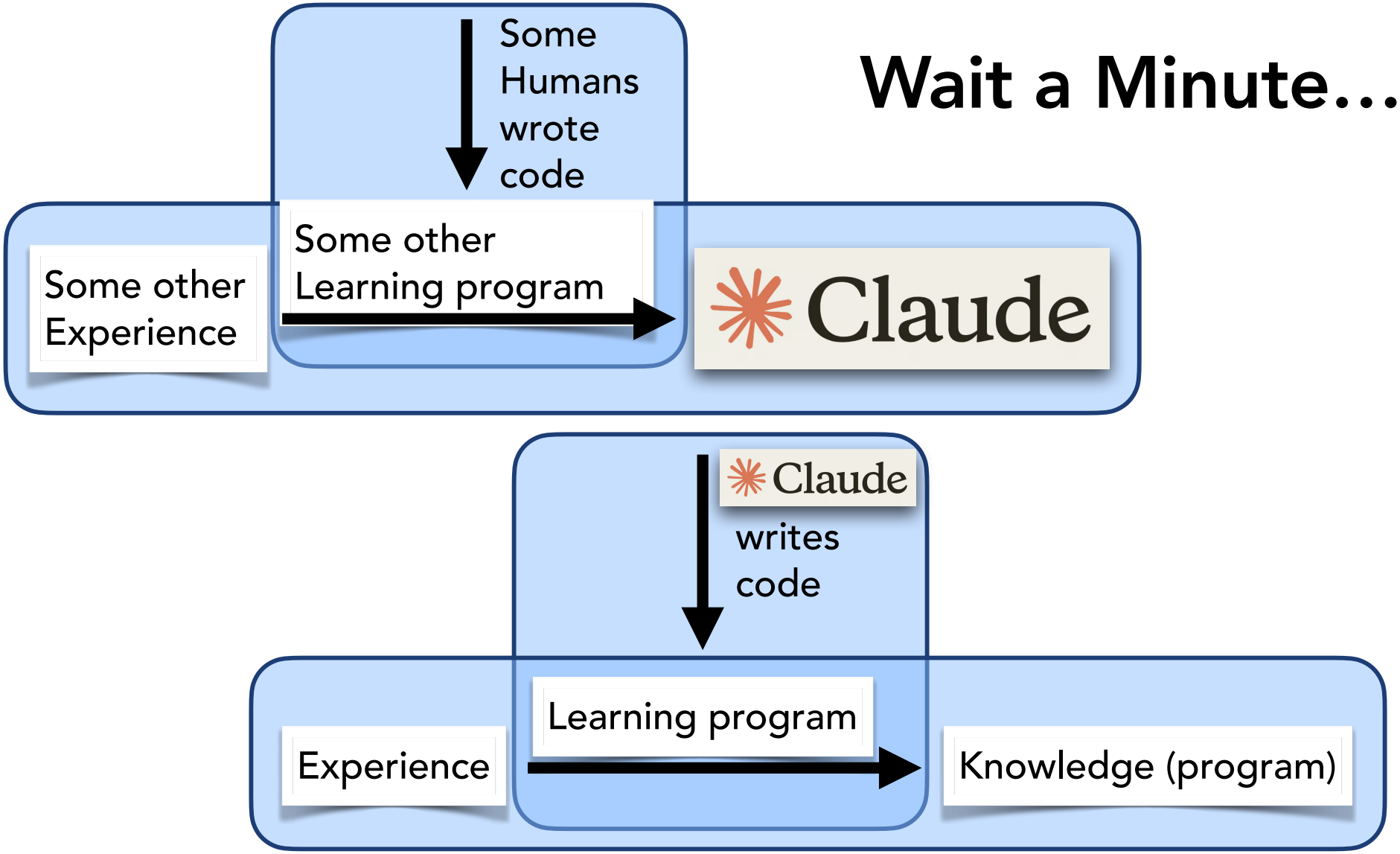

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My Answer:

1. If something doesn't work, then you can fix it
2. Better know when something is not working
3. Its fun and feels like magic :)