TEACHER GUIDE

LEARNING UNDEFEATED
Educate | Elevate | Empower

AI Decision Trees

Topic(s): Artificial intelligence, Decision trees, Classification systems

Grade level(s): 9-12

Time: 45 – 60 minutes

NGSS Standards Alignment: HS-ETS1-2, HS-LS1-2

ACTIVITY OVERVIEW

In this lesson, students will explore how artificial intelligence systems classify information using decision trees, a foundational machine learning concept. Through collaborative group work, students will create their own decision trees to classify a set of object cards using yes/no questions. They will then test another group's tree, simulating how AI models are trained and evaluated. The activity encourages critical thinking about logic design, precision in language, and real-world AI applications such as spam filtering, medical diagnoses, and product recommendations.

Table of Contents

ALIGNMENT TO STANDARDS

Next Generation Science Standards (NGSS)

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems.
HS-LS1-2: Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

Texas Essential Knowledge and Skills (TEKS)

BIO.1.G: Develop and use models to represent phenomena, systems, processes, or solutions to engineering problems
BIO.5.A: Relate the functions of different types of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids, to the structure and function of a cell
BIO.5.B: Compare and contrast prokaryotic and eukaryotic cells, including their complexity, and compare and contrast scientific explanations for cellular complexity
BIO.12.A: Analyze the interactions that occur among systems that perform the functions of regulation, nutrient absorption, reproduction, and defense from injury or illness in animals
BIO.12.B: Explain how the interactions that occur among systems that perform functions of transport, reproduction, and response in plants are facilitated by their structures

Virginia Standards of Learning (SOL)

BIO.3.B: structures in unicellular and multicellular organisms work interdependently to carry out life processes
BIO.4.C: The structures and functions can be compared
BIO.6.F: Systems of classification are adaptable to new scientific discoveries

LEARNING OUTCOMES

Students will know:

- The structure and function of decision trees in AI systems.
- The importance of clear, logical questioning in data classification.

Students will understand:

- How real-world AI breaks down complex problems into simpler yes/no decisions.
- The limitations of decision trees when data is ambiguous or improperly structured.

Students will be able to:

- Build and test a classification model using a decision tree.
- Analyze the effectiveness of a classification system and suggest improvements.
- Communicate reasoning and troubleshoot logic flaws.

CAREER CONNECTIONS

Data Scientist

Data scientists use analytical tools and techniques to extract meaningful insights from data.

Work Environment: Workers are generally employed by computer systems design companies and work primarily in office settings.

Duties: Professionals in these jobs have the following duties and more: determine which data are available and useful for the project, create, validate, test, and update algorithms and models, and use data visualization software to present findings.

Median Salary: $112,590 (US Bureau of Labor, 2024)

Source: BLS Occupational Outlook Handbook: Data Scientists

Computer Programmers

Computer programmers write, modify, and test code and scripts that allow computer software and applications to function properly.

Work Environment: Programmers usually work in office settings, most commonly in the computer systems design and related services industry. Most computer programmers work full time.

Duties: Professionals in these jobs have the following duties and more: write programs in a variety of computer languages, such as C++ and Java, test programs for errors and fix the faulty lines of computer code, and create, modify, and test code or scripts in software that simplifies development.

Median Salary: $98,670 (US Bureau of Labor, 2024)

Source: BLS Occupational Outlook Handbook: Computer Programmers

Database Administrators and Architects

Database administrators and architects create or organize systems to store and secure a variety of data, such as financial information and customer shipping records. They also make sure that the data are available to authorized users.

Work Environment: Many database administrators and architects work in firms that provide computer design services or in industries that have large databases, such educational institutions and insurance companies. Most database administrators and architects work full time.

Duties: Professionals in these jobs have the following duties and more: design and build new databases, ensure that organizational data are secure, and ensure that databases operate efficiently and without error.

Median Salary: $123,100 (US Bureau of Labor, 2024)

Source: BLS Occupational Outlook Handbook: Database Architects

BACKGROUND INFORMATION

Decision trees are among the simplest and most interpretable models in AI. They break down data into binary choices (yes/no, true/false) to classify items or make predictions. Though modern AI uses more complex models like neural networks, decision trees remain foundational for:

- Explainable AI: Easy to understand and visualize.
- Real-world use: Spam filters, medical triage, credit approvals.
- Fast computation: Quick decisions with large datasets.

Key Concepts:

- *Node*: Represents a question or test on an attribute.
- *Branch:* Outcome of the test (yes/no).
- *Leaf Node:* Final classification (e.g., "dog," "metal object," "spam").
- *Overfitting:* A tree that's too specific may not handle new data well.
- *Pruning:* Simplifying the tree to avoid errors and improve efficiency.

Why It Matters in AI:
AI systems process millions of data points quickly but still rely on clear logic. Ambiguity can lead to bias, misclassification, or unintended consequences (e.g., facial recognition errors). Students gain insight into how small errors in design lead to big AI mistakes.

Resources for AI and Decision Trees

- Decision Trees Explained by Data Science Dojo (Video, 6:27)
- Decision Trees: 1 Easy Way to Make a Model in Science Class by REAL Science Challenge (Video, 4:21)
- Morse Code Using a Binary Tree by 101 Computing

MATERIALS PREPARATIONS

- Print and cut out object cards.
    - There are 6 prepared themes of cards that cover variety of different science topics. Each theme includes 5 different sets of cards that can be distributed to students. Each theme can be downloaded from our website.
        - Body Systems and Organs
        - Plant Biology
        - Cell and Molecular Biology
        - Microbiology
        - Animals and Classification
        - Ecology and the Environment
    - You can add subject cards based on teaching and student needs, as well as content. You may want to review cards with students before using them. You may also want to print, cut, and laminate the cards for future use.
- Prepare large poster paper or whiteboard space for each group.
- Provide sticky notes for flexible question placement.
- Have markers or pens available.

STUDENT STATION SET-UP

Students will work in small groups of 4-5 with the following materials

- 1 set of object cards (8 cards total)
- Poster paper/ whiteboard
- Sticky notes
- Pens/ markers
- Student handout

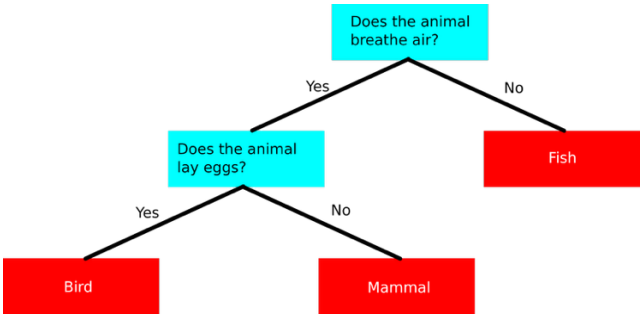
LESSON PLAN

Warm Up (5 minutes)

- Begin by welcoming students and setting the tone for the lesson. Write the day's objectives on the board or project them:
    - Objective: Students will understand how AI classifies information and develop systematic thinking skills by creating and testing decision trees.
- Give students the opportunity to think about and respond to the three questions regarding the objective. If you like, you can provide sentence starters to help students frame their thinking:
    - What are you doing today? "Today I will learn …"
        - Potential student response: Today, I will learn how to create and test a decision tree, like AI does.
    - Why is this important? "This is important because …"
        - Potential student response: This is important because AI is part of everyday life, and it's important to understand how it works—and what can go wrong if the logic is unclear.
    - How will you know if you have done well? "I'll know I've done well if…"
        - Potential student response: I'll know I've done well if my decision tree helps another group correctly classify the objects without confusion.
- Explain that today we're stepping into the role of AI systems. You'll learn how artificial intelligence classifies things by breaking down complicated questions into simple yes/no decisions. This skill is part of how computers make decisions about what you see online, how medical diagnoses are suggested, or even how your phone knows whether you're asking for a weather report or setting a reminder.

Introduction (5 minutes)

- Ask students: "Have you ever played 20 Questions to figure out what someone is thinking of?"
    - Allow a few students to respond. Build a quick connection:
- Explain that AI works in a similar way—but instead of playing a game, it's making decisions using data. When you open your photo app and it suggests who is in a picture, or when YouTube recommends your next video, AI is asking internal questions like: Is this person smiling? Is it daytime? Have they watched this type of video before? It uses something called a decision tree to sort through these options quickly.
- Show a visual of a simple decision tree (on the board or projector). For example:



- Explain that decision trees help AI systems take complex data and break it into small, answerable pieces. Today, you'll build your own decision tree to see how this works.

Setup Phase (5 minutes)

- Divide students into groups of 4-5 and direct them to the prepared student stations or distribute all necessary materials.
    - To save time, you can use pre-established areas for group materials.
- You can also assign group roles and their responsibilities. For example:
    - Question Recorder
        - Drafts the yes/no questions for the decision tree.
        - Ensures questions are clear, objective, and specific.
        - Works with the group to refine wording.
    - Tree Architect (Recorder/Mapper)
        - Draws the tree structure on the poster paper or whiteboard.
        - Organizes the sticky notes into a logical sequence of branches.
        - Checks that all object cards have a path to classification.
    - Card Master (Data Handler)
        - Reads out the object cards to the group.
        - Helps the group think about how to classify each object.
        - Keeps track of which items have been covered.
    - Quality Control (Logic Tester)
        - Looks for logical gaps or unclear wording.
        - Tests the tree on a few sample cards before swapping with another group.
        - Flags any confusion before the official test phase.
    - Presenter (if 5th member is present)
        - Summarizes the group's decision tree design for the class.
        - Shares findings during the reflection discussion.
        - Explains what worked and what challenges the group faced.
- Explain the task to the class: Your group will build a decision tree that can classify all the objects in your card set. You'll write each question on a sticky note, starting with big categories and moving to more specific ones. Make sure your questions are clear, specific, and have a definite yes or no answer.
- Check with students before releasing them to the activity by having students paraphrase what they will be doing. Ask "What questions do you have?"

Part 1: Build the Decision Tree (10 minutes)

- Remind students:
    - Start with broad questions first.
    - Use clear, measurable language (e.g., "Does it have DNA?" instead of "Is it complicated?").
    - Place the sticky notes on the poster or whiteboard to create branches.
    - They may use their notes or provided resource sheets.
- Possible dialogue:

    - Think about how a scientist or a computer would need to classify this. What is the simplest question you can ask to split your set of cards into two parts?
    - Remember: AI systems don't guess. They follow the path exactly as you program it, so make sure each question is unambiguous.
    - If you get stuck, try thinking about physical properties, use, category, or function.
- Circulate to support groups, clarify questions, and redirect if needed.

Part 2: Test the Decision Trees (10 minutes)

- After each group finishes their decision tree, have groups swap trees and card sets.
- Direct each group will use the decision tree to try to identify the objects from the cards.
- Remind students to:
    - Follow the yes/no pathways exactly as written—no changes!
    - Track how many objects are correctly classified.
    - Optional: Have students assign a confidence score (1–10) to each guess to mimic AI uncertainty.
- Possible Teacher Dialogue:
    - Pretend you are the AI now. You can't read minds—you can only follow the tree exactly. If a question is unclear, you'll have to make a best guess or mark it as confusing. This is what happens when AI deals with bad data!

Analysis and Discussion (10 minutes)

- Facilitate a class discussion using the reflection questions on the student handout. Encourage students to refer to specific examples from their experience.
    - Let's start by thinking about how efficient your decision trees were. How many questions did it take for your group to classify all of your cards?
        - Follow-up prompts:
            - Did you find that you asked too many questions, or not enough?
            - Could you have made your tree shorter by combining ideas or starting with broader questions?
            - In AI, fewer steps usually mean faster processing, but we have to balance that with accuracy.
    - Were there any cards that gave you trouble—ones that didn't fit neatly into your yes/no questions?
        - Follow-up dialogue:
            - Why do you think that happened? Was it because the object had more than one possible category? Or were the questions too narrow?
            - This is exactly what happens in real AI systems. Some things don't fit into neat boxes, and the system has to make a decision anyway. Sometimes, that's where mistakes happen.
    - Decision trees aren't just a classroom activity—they're used all around us in technology. Can anyone give an example of a real-world AI system that might use a decision tree?

        - If students need prompting:
            - Think about apps you use—how does your email know what's spam and what's not? How does Netflix or YouTube recommend what to watch next?
            - Healthcare is another area: AI might use a decision tree to help doctors decide on a diagnosis based on symptoms.
            - What other examples can you think of?
    - AI systems often deal with problems way more complex than what we did today. How do you think AI handles these huge tasks when humans might struggle?
        - Follow up prompts:
            - AI can process millions of data points at once—that's something our brains just can't do that fast.
            - It can look for patterns that humans might miss, but it still needs clear instructions to start with. That's why models like decision trees are important.
            - What other advantages or challenges do you think AI has compared to people?
    - This last one is really important for understanding AI. Why do you think it's so critical that AI systems start with clear, simple questions?
        - Possible responses and prompts:
            - Right! If the first question is confusing, the whole system can make mistakes afterward.
            - Think about AI in real life: If a system misunderstands the first input, it might recommend the wrong product, send you the wrong ad, or even misdiagnose a medical condition.
            - This shows how important it is for the people building AI to design systems that are precise and fair.
- Congratulate students for flexing their AI skills: Today you all thought like AI engineers! You practiced breaking down big problems into small decisions, just like real-world AI does. Remember, technology can only be as good as the logic and data we give it—so clear thinking and careful design really matter.

MISCONCEPTIONS TO ADDRESS

- Misconception 1: AI "thinks" and "understands" like a human.
    - Explain that AI does not think or have consciousness—it follows programmed rules and logic.
    - Use an analogy: "AI is like a very fast and complex calculator. It doesn't have feelings or understanding; it just follows instructions exactly."
    - Emphasize the role of data and clear rules for AI decisions, unlike human intuition.
- Misconception 2: Any question can be used in a decision tree.
    - Clarify that questions must have a clear yes/no answer to keep the decision tree working.
    - Show examples of vague questions ("Is it interesting?") versus good questions ("Is it made of metal?").
    - Have students practice rewriting vague questions into clear yes/no questions.
- Misconception 3: The more questions, the better the classification.
    - Explain that while more questions can add detail, too many questions can make the system slow or overly complicated (overfitting).
    - Encourage students to balance efficiency with accuracy—fewer questions that clearly separate groups are ideal.
    - Use examples: a very long decision tree might confuse AI or users.
- Misconception 4: AI systems always make perfect or "correct" decisions.
    - Discuss real-world AI failures and errors, like misclassifications in facial recognition or spam filters.
    - Emphasize that AI depends on the quality of data and design—bad data or unclear questions lead to mistakes.
    - Show how testing and refining are crucial steps in AI development.
- Misconception 5: Decision trees are the only or best way AI makes decisions.
    - Teach that decision trees are just one of many AI methods (others include neural networks, clustering, etc.).
    - Highlight that decision trees are great for explainability but not always the most powerful for all tasks.
    - Suggest further exploration for advanced students interested in different AI models.
- Misconception 6: If an object is hard to classify, the AI must be broken or faulty.
    - Explain that some objects or data are inherently ambiguous or complex and that this is a challenge even for humans.
    - Encourage thinking about how AI must deal with uncertainty and sometimes give "best guess" answers.
    - Introduce concepts like confidence scores or probability to show how AI expresses uncertainty.

OPTIONAL EXTENSIONS

- *Optimization Challenge:* Have students try to minimize the number of questions needed.
- *STEM Integration:* Compare decision trees to dichotomous keys (biology) or binary search trees (computer science).
- *Real-World Scenario Writing:* Ask students to write a paragraph describing how a decision tree could be used in AI outside of class.