Lesson 02: Mystery Graphs (High-Inquiry Version)

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Lesson Title: What Could This Graph Show? Generating and Testing Hypotheses
Intended Grade Level(s): Grades 6-12 (adaptable)
Content Area: Content-Agnostic Data Interpretation

I. Planning

Lesson Focus / Goals

State the big idea(s) of the lesson. Focus on conceptual understanding. Avoid vague objectives. Specify the knowledge and skills students should demonstrate.

The lesson aims to provide the following for students: - Generate multiple plausible hypotheses about what unlabeled graphs represent - Use graph features (shape, trend, scale) as evidence to evaluate and compare hypotheses - Distinguish between hypotheses that fit the data well vs. poorly, and articulate why - Experience authentic scientific reasoning: proposing, testing, and revising explanations - Understand that graphs are tools for reasoning about relationships, not just correct labeling

Learning Objectives

Write clear, measurable objectives. Include both procedural and conceptual goals. Consider potential misconceptions students might have.

By the end of the lesson, students will be able to: - Generate 2-3 plausible hypotheses for what an unlabeled graph could represent - Use specific graph features (shape, trend, endpoints, rate of change) as evidence to support or reject hypotheses - Distinguish between hypotheses that “fit” the data well vs. poorly, and explain why - Evaluate competing hypotheses by identifying which features each explains - Compare graph shapes across different phenomena to identify relationship types

Potential Misconceptions: - Students might think there’s only ONE correct answer the teacher knows - Students might propose hypotheses without checking if features actually match - Students might not distinguish between “possible” and “plausible” (any idea vs. evidence-based) - Students might think any creative idea is equally valid regardless of evidence - Students might focus only on trend (up/down) without considering shape, rate, or mechanisms

Standards Alignment

Note: This is a content-agnostic lesson that places math and science students on equal footing. However, the reasoning processes naturally align to core practices in both disciplines.

Standards for Mathematical Practice (Common Core): - MP2 – Reason abstractly and quantitatively.
Students interpret graphs as representations of quantitative relationships. **- MP6** – Attend to precision.
Students use precise vocabulary when describing graph features.

NGSS Science and Engineering Practices: - Analyzing and Interpreting Data – Students examine graphical representations to identify patterns and relationships. **- Using Mathematics and Computational Thinking** – Students recognize how graphs model real-world phenomena.

II. Implementation

Materials Needed

List all physical and digital resources, manipulatives, and technology needed. For each item listed, provide a brief justification/explanation for its inclusion.

- **Three mystery graphs** (fewer than LOW version because deeper engagement per graph) showing different relationship types: (1) rapid-then-leveling curve, (2) steady linear increase, (3) cyclical pattern
- **Hypothesis generation sheets** with space for multiple interpretations per graph and evidence columns
- **Chart paper or whiteboards** for small groups to display competing hypotheses
- **Graph features anchor chart** (trend, shape, rate of change, endpoints, mechanisms)
- **"What wouldn't work?" prompts** to push constraint-based reasoning

Preparation: Select 3 graphs with distinct shapes but multiple plausible interpretations. Teacher has identified 3-4 possible phenomena per graph but does NOT privilege one as "correct"—uses them to validate student reasoning and probe for better evidence. Prepare hypothesis sheets and anchor charts.

Lesson Flow

(Before-During-After)

Organize your plan using the Before–During–After framework. Include approximate timing, key questions, and anticipated student responses.

Before: Launch & Frame the Challenge (8 min) **[CORE]** 1. Display **Graph 1** (unlabeled curve showing rapid initial increase that levels off) - NO LABELS 2. Ask: "What could this graph be showing? Turn and talk for 30 seconds." 3. Collect 3-4 different hypotheses publicly without evaluating them 4. Frame the challenge: "Today you're going to work like scientists and mathematicians do with data—you'll see unlabeled graphs and generate hypotheses about what they could show. Then you'll use the graph's features as evidence." 5. Show **Graph Features Anchor Chart**: "When evaluating if a hypothesis fits, we look at: - **Shape**: Straight? Curved? How? - **Trend**: Going up? Down? Leveling? - **Rate of change**: Fast? Slow? Changing? - **Endpoints**: Where does it start/end?"

During: Generate & Test Hypotheses (25 min) **[CORE - though time can be compressed if needed]**

Part 1: Generate & Test Hypotheses (Graph 2 - Steady Linear Increase) - Display **Graph 2** (unlabeled steady linear increase) - Small groups (3-4 students) work together: "Generate at least 2 different hypotheses for what this could show. For each one, explain WHICH features make it plausible." (5 min) - Groups record on chart paper with two columns: Hypothesis | Evidence from Graph - Teacher circulates with probing questions: - "What's different about this shape compared to Graph 1?" - "Would this graph work for something that grows fast then slows? Why not?" - "What tells you this is steady growth?" - Gallery walk (2 min): Groups view other hypotheses silently - Whole class: "Which hypothesis do you think fits BEST? Why?" (3 min) - Push for comparative reasoning: "Both could work, but which features does each explain better?" - Introduce constraint: "What would NOT work here? Why?" (e.g., "Could this be coffee cooling? Why not?") #### After: Cross-Graph Synthesis & Meta-Cognitive Reflection (10 min) **[CORE for cross-graph comparison; meta-cognitive reflection is EXTENSIBLE/OPTIONAL]**

Cross-Graph Comparison: - Display all 3 graphs side-by-side - Ask: "Looking across these graphs, what did you notice about how shape connects to relationships?" - Guide toward big ideas: - Different phenomena can produce similar shapes - The shape reveals the TYPE of relationship (steady growth, leveling off, cyclical) - Specific features help us narrow down plausible interpretations

Meta-Cognitive Reflection: **[EXTENSIBLE/OPTIONAL]** - "When you were testing hypotheses, what made you reject one as 'not fitting'?" - "What's the difference between a hypothesis that's *possible* and one that's *plausible*?" - Surface: Plausible = accounts for multiple specific features, has a mechanism that makes sense

Transfer Question: **[EXTENSIBLE/OPTIONAL]** - "Think about your own content area. When might you encounter data where you need to infer what's happening rather than being told?" - Math examples: analyzing real-world data sets, modeling scenarios - Science examples: interpreting experimental results, reading published graphs - Emphasize: "Graphs aren't just about reading correctly—they're tools for reasoning about relationships"

Formative Assessment Strategies

Describe how you will check for understanding during and after the lesson.

During Group Work: - Monitor chart papers for number and quality of hypotheses - Listen for evidence-based reasoning: Are students citing specific graph features? - Watch for constraint-based thinking: Are students evaluating what WOULDN'T work? - Note groups that generate hypotheses without testing them against features

During Discussions: - Listen for comparative reasoning: "This fits better because…" - Monitor for mechanistic explanations: "This shape happens because…" - Check if students distinguish between possible and plausible - Note whether students push each other's reasoning or just accept ideas

Exit Ticket: [**CORE**] Students receive one final mystery graph (exponential decay: coffee cooling OR phone battery draining OR bounce height after repeated drops). They must: 1. Generate 2 plausible hypotheses 2. For each, cite specific graph features as evidence 3. Explain which hypothesis they think fits BEST and why 4. Identify one hypothesis that WOULDN'T work and explain which feature rules it out

Self-Assessment: [**EXTENSIBLE/OPTIONAL**] Students reflect: "What was harder—generating ideas or testing them against the graph? Why?"

III. Student Handouts

Hypothesis Generation Sheet

Group Members: ______________________________ **Date:** ______________________________

Mystery Graphs - Generating and Testing Hypotheses

For each graph, generate at least 2 plausible hypotheses. For each hypothesis, cite SPECIFIC graph features as evidence.

Graph 1: Example (Rapid-Then-Leveling Curve)

Hypothesis	Evidence from Graph Features
Baby weight in first year	Starts low, increases rapidly (steep curve at start), then levels off as growth slows—matches typical infant growth pattern
Learning a new skill (hours practicing vs. performance)	Rapid improvement at first (steep slope), then smaller gains as you approach mastery (leveling off)

What WOULDN'T work? Tree growth—trees grow steadily for decades, wouldn't level off this quickly

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Graph 2: (Steady Linear Increase)

Hypothesis	Evidence from Graph Features
1. ______________________________	______________________________
2. ______________________________	______________________________

What WOULDN'T work here? ______________________________

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Graph 3: (Cyclical/Wave Pattern)

Hypothesis	Evidence from Graph Features
1. ______________________________	______________________________
2. ______________________________	______________________________

Which hypothesis fits BEST? Why? ______________________________

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Cross-Graph Reflection

Looking at all 3 graphs, what did you notice about how shape connects to the TYPE of relationship?

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Exit Ticket (Individual)

Mystery Graph #4: [Exponential decay curve shown]

1. Generate 2 plausible hypotheses:

Hypothesis A: ______________________________
Evidence: ______________________________

Hypothesis B: ______________________________
Evidence: ______________________________

2. Which fits BEST? Why?

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3. What's one hypothesis that WOULDN'T work? Why not?

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V. Further Revision Ideas

These are additional inquiry-enhancing moves suggested through analysis of the lesson's revision capacity. While not included in this version, they represent growth opportunities for continued development.

Strengthen Collaborative Argumentation Structures (Dimension 7)

- Add formal debate protocol: Groups publicly defend their "best fit" hypothesis while others challenge with counter-evidence
- Use "convince your skeptical partner" structure where students must persuade someone who disagrees
- This pushes beyond listing ideas to genuine argumentation about evidence quality

Add Graph Family Sorting Activity (Dimension 10)

- After experiencing all graphs, give students 6-8 unlabeled graphs and ask: "Sort these into families by relationship type"

- Name the families together: growth-then-leveling, steady change, cyclical, exponential decay
- Connect families to mathematical functions or scientific processes
- This deepens pattern recognition and meta-cognitive awareness

Extend Ceiling with Graph Creation Challenge (Dimension 2)

- "Create your own mystery graph for a phenomenon you know well. Make it challenging but solvable."
- Students must articulate what features provide clues and what alternative interpretations might work
- Requires understanding what makes evidence compelling, not just using it

Layer Increasingly Constrained Reasoning (Dimension 2)

- Start with only shape visible, then progressively reveal: axis labels without units, then units, then partial data table
- Ask: "How does each new piece of information change which hypotheses are plausible?"
- Makes the role of constraints explicit and visible

Add Unit/Scale Analysis (Dimension 4)

- Provide hypotheses WITH proposed units: "This is temperature over months (°F)" vs. "This is temperature over months (°C)"
- Ask: "Does the scale match? What would we expect for each?"
- Deepens context-rich reasoning and quantitative evaluation

Capacity Analysis Summary

Why This Lesson Has Very High Revision Capacity:

This lesson is **structurally clean but epistemically constrained** in its LOW version. Revision capacity comes from a different place than Lesson 01: - **Lesson 01** → authority & openness are the main levers (who decides what counts) - **Lesson 02** → epistemic framing & sense-making vs. labeling are the levers (interpretation WITH risk vs. after-the-fact explanation)

Key Insight: This lesson makes visible the difference between *"reading a graph correctly"* vs. *"using a graph to reason about the world."*

Very High/High-Capacity Dimensions for Novice Revision:

1. **Curiosity** (VERY HIGH) - "Mystery graphs" inherently puzzle; curiosity is repeatedly resolved too fast in LOW version; inquiry revision is largely subtractive

2. **Openness & Multiple Pathways** (HIGH) - Unlabeled graphs naturally invite multiple plausible interpretations; teacher suppression is easily removed
3. **Low Floor / High Ceiling** (HIGH) - Anyone can describe trends; ceiling artificially capped by reveal-and-record structure; releasing it is accessible
4. **Context-Rich/Phenomena-Based** (HIGH) - Every graph already corresponds to real phenomena; context is withheld, not absent—excellent for revision
5. **Causal Explanation** (HIGH) - Mechanistic language exists but causality is asserted, not reasoned; novices can shift to student-enacted "why"
6. **Integration of Big Ideas** (HIGH) - "Graphs as representations of relationships" already gestured at; making it explicit is straightforward

Medium-High Capacity Dimensions:

7. **Student Agency** (MEDIUM-HIGH) - Students notice but never decide what wins; shifting justification to peer audiences is slightly harder than WODB
8. **Problem Before Method** (MEDIUM-HIGH) - Students encounter problem first but method immediately supplied; temporal revisions similar to Lesson 01
9. **Connection-Making** (MEDIUM-HIGH) - Multiple graphs invite comparison; adding comparison structures is natural extension

Medium Capacity Dimensions:

10. **Collaboration & Discourse** (MEDIUM) - Talk exists as idea-sampling only; structuring argumentation may require more support

Why This Is an Especially Strong Low Anchor:

1. **Inquiry lives in interpretation, not correctness** - Powerful conceptual shift for secondary candidates
2. **Math and science candidates both have leverage** - Shapes, mechanisms, and plausibility cross disciplines cleanly
3. **Bad revisions are still instructive** - Even shallow moves (e.g., "more discussion") expose what's missing
4. **The epistemic shift is visible** - Students can feel the difference between being told vs. figuring out