ENGINEERING DRAWING

# Module 2: 2D and 3D – Unboxing 3D Shapes

Teacher Facilitation Guide

Grade: 6th–8th

Duration: ~1 Week (3 Class Periods)

## Module Overview

In Module 1, students discovered that informal sketching cannot reliably communicate a 3D design. This module bridges that gap by exploring nets — the 2D shapes you get when you unfold a 3D object flat. Students predict, draw, cut, and verify nets of cube structures, discovering why a complete net must include every exposed face. That idea of completeness — that every face counts — sets up both the 3-view drawing standard in Module 3 and the surface area calculations in Module 4.

**BY THE END OF THIS MODULE, STUDENTS WILL BE ABLE TO:**

- Explain in their own words the relationship between a 3D object and its 2D net
- Draw a valid net of a single cube on graph paper, label all six faces, and verify it by cutting and folding
- Explain why a cube has exactly 6 faces and why a net must include all of them
- Determine the number of exposed faces on a multi-cube structure and explain why internal faces are not counted
- Connect the number of squares in a net to the surface area of the 3D structure

**MATERIALS**

- Small (1") wooden cubes — 2 to 4 per student
- Graph paper and blank paper
- Pencils and small rulers
- Scissors and tape (for net construction)

**MODULE STRUCTURE**

- Activity 1 — What Is a Net? Unfolding and Predicting (Day 1)
- Activity 2 — Drawing and Building Nets (Day 2)
- Activity 3 — Nets of Multi-Cube Structures (Day 3)

## Standards & Learning Goals

| Standard | Details |
|---|---|
| **Georgia Standards of Excellence** | Grade 6: EET-1, EET-7 \| Grade 7: II-3, II-7 \| Grade 8: TS-2, TS-7 |
| **NGSS Standard** | MS-ETS1: Engineering Design |
| **Performance Expectation MSETS1-1** | Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution. |
| **Common Core Math 6.G.A.4** | Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. |

| Learning Dimension | Classroom Connections |
|---|---|
| **Science and Engineering Practice**<br>*Constructing Explanations and Designing Solutions:* Students investigate the relationship between 2D nets and 3D objects, developing and testing predictions about which net patterns fold into valid cubes. They evaluate their nets for completeness and explain why a net with fewer than the correct number of faces cannot represent the object. | In Activity 1, students predict what shape a cube produces when unfolded — constructing and testing an explanation before seeing the answer. In Activity 2, students draw, cut, and fold their own nets, evaluating each for validity. In Activity 3, students discover that joining cubes hides internal faces, and must construct an explanation for why the face count changes. |
| **Disciplinary Core Idea**<br>*MS-ETS1-1: Defining and Delimiting Engineering Problems*<br>A net must include all exposed faces of a 3D object — no more, no fewer. This is an engineering constraint: an incomplete net cannot encode complete information about the object. Students experience this constraint directly when they discover that a net with a missing face does not fold into a complete cube. | Students discover through the face-counting work in Activity 3 that drawings and representations must be complete to be useful. The idea that a representation with missing information is an engineering problem — not just an academic error — is a concrete application of the design constraint concept from Module 1. |
| **Crosscutting Concept**<br>*Structure and Function:* The structure of a net — which faces are included and how they are connected — determines its function as a representation of a 3D object. Different nets of the same cube have different structures but fold into the same 3D form.<br><br>*Scale, Proportion, and Quantity:* A net drawn to scale preserves the proportions of each face. Students draw nets on graph paper using the cube's actual dimensions and verify that each face's dimensions match the physical cube. | In Activity 1, students unfold cube structures to produce nets, directly experiencing the structure-function relationship: a net's layout determines whether it folds into the correct object. In Activity 2, students use graph paper to maintain accurate scale, reinforcing the connection between proportional drawing and the 3D object. |

## Engineering Skill Learning Goals

- Students visualize 3D objects as flat 2D shapes by predicting and constructing nets, developing spatial reasoning that carries into 3-view drawing.
- Students build vocabulary for describing the relationship between 2D and 3D representations — net, face, exposed face, internal face — and use that vocabulary to explain their reasoning.
- Students construct and verify nets of cube structures, learning to check their own work by folding.
- Students discover that joining cubes changes the face count, and connect this discovery to the engineering idea that a complete representation must account for every exposed surface.
- Students make the first explicit connection between nets and surface area, previewing the systematic calculations in Module 4.

## Key Vocabulary

These words are introduced in Module 2 and carry forward into Modules 3 and 4. Reinforce vocabulary from Module 1 (face, edge, vertex) as these activities build on those concepts.

| Term | Definition |
|---|---|
| **Net** | A 2D shape that you can cut out and fold up to make a 3D object. If you unfold a cube by cutting along some of its edges and laying it flat, you get a net of that cube. |
| **Exposed Face** | A face on the outside of a cube structure that you can see and touch. When cubes are joined together, the faces where they touch become hidden — they are no longer exposed. |
| **Internal Face** | A face that is hidden because it is shared between two joined cubes. Internal faces are not part of the net because they are not part of the surface. |
| **Surface Area** | The total area of all the exposed faces of a 3D object. In Module 4, students will calculate surface area systematically — but in this module, counting the squares in a net gives a preview of the idea. |
| **Valid Net** | A net that, when folded, produces the 3D object without gaps or overlapping faces. A valid net of a single cube has exactly 6 squares, all connected. |

## ACTIVITY 1

### What Is a Net? Unfolding and Predicting

*Essential Question: What shape do you get when you unfold a 3D object flat?*

TIME
**~50 min**

**WHY NETS?**

A net is the 2D shape you get when you unfold a 3D object flat. Every face of the 3D object becomes a flat shape in the net. This means a net contains complete information about all the faces of an object — which is exactly what engineers need when they draw.

Nets also connect directly to surface area (Module 4): the area of a net is the surface area of the 3D object it folds into. Students who understand nets have a powerful visual tool for counting faces and calculating surface area.

### Part 1 — Predict the Net (15 minutes)

Give each student a single small cube and a blank sheet of paper. Ask: "If I unfolded this cube — cut along some edges and laid it flat — what shape would I get?" Have students sketch their prediction before touching the cube, then compare with a partner:

- Did you predict the same shape? What is similar or different?
- How many squares does your predicted net have? (If not 6, what might be missing?)
- Do all the squares in your net connect to each other?

### Part 2 — Exploring Valid Nets (20 minutes)

Have students cut out and tape together the 1 cube net on the One Cube Student Sheet. Then, ask students try drawing their own net for a cube. Valid nets will have the following properties:

- They all have exactly 6 squares — one for each face of the cube
- All the squares are connected — no gaps
- They all fold back into a cube
- None of the squares overlap when folded

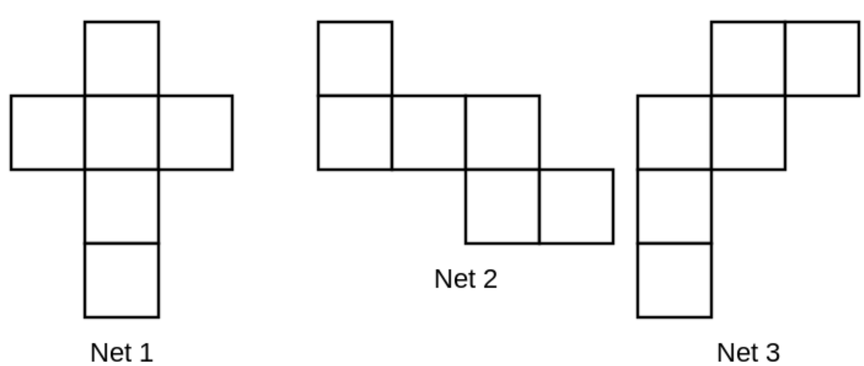



Figure 1. Three valid cube nets

**TEACHER NOTES**

**Key insight to draw out:** A cube has 6 faces, so every net of a cube has exactly 6 squares. There is no net with 5 squares that folds into a complete cube — one face would always be missing. This is the same idea as engineering drawing: you need to show all the faces to give complete information.

Extension: Can students find a second valid net pattern? A third? (There are 11 total for a single cube.)

### Part 3 — Class Discussion (15 minutes)

**DISCUSSION QUESTIONS**

- Why does a net of a cube need exactly 6 squares — no more, no fewer?
- What would happen if you tried to build a cube from a net with only 5 squares? (One face would be missing — the cube would be open on one side.)
- What would happen if you tried to build from a net with 7 squares? (One face would overlap another — the net would not fold flat.)
- In your prediction, did you get 6 squares? If not, which face did you forget?

**JOURNAL PROMPT**

In your own words:

- What is a net? Use the word 'face' in your answer.
- How many faces does a cube have? How does that number connect to the number of squares in its net?
- What surprised you about the different valid nets? What stayed the same across all of them?

# ACTIVITY 2

## Drawing and Building Nets

*Essential Question: Can you draw a net that folds back into the original cube?*

TIME
**~50 min**

Students draw a net of a single cube on graph paper, using the cube's actual dimensions (1 inch per square). The goal is not just to draw correctly — it is to verify by doing: if the net folds into the cube, it is valid. If it does not, something is wrong, and that is useful information.

> **TEACHER NOTES**
>
> **Framing for students:** "Today you are going to design something. Your net has to meet two requirements: it has to be drawn accurately to scale, and it has to fold into a cube. Those are your criteria. If your net fails either one, it goes back to the drawing board — which is exactly what engineers do."

### Part 1 — Draw a Net on Graph Paper (20 minutes)

Students draw a net of a single cube on graph paper, using 1 square per cube face (each small cube is 1 inch, so each face is 1 square on the graph paper). They should:

- Choose one of the valid net patterns discussed in Activity 1 and draw it on graph paper
- Label each square with the face name it represents: Top, Bottom, Front, Back, Left, Right
- Before cutting, count: are there exactly 6 squares? Are they all connected? Do any overlap when folded?

> **TEACHER NOTES**
>
> **Common mistake:** Students sometimes draw a net that looks right but does not fold correctly — two faces end up overlapping, or a face is missing. This is a useful error: ask students to count the squares before cutting. Six squares, all connected, no overlaps = a valid net.
>
> **Scaffolding**: Students who struggle with predicting can trace the cube faces directly onto graph paper, then rearrange the cut-out squares into a connected layout before drawing the final net.

### Part 2 — Cut and Fold to Verify (20 minutes)

Students cut out their net and fold it to verify it makes a cube. Tape the edges closed.

- Does it fold into a closed cube with no gaps?
- Are all 6 faces present? Can you find Top, Bottom, Front, Back, Left, and Right?
- If your net does not fold correctly, unfold it and look at what went wrong — then redraw.

> **TEACHER NOTES**
>
> The folding check is important. Students who drew an invalid net will discover it here, not from teacher correction. Ask them: "*What went wrong? Which face was in the wrong place?*' This moment of debugging is where the spatial reasoning deepens.

### Part 3 — Can You Find a Different Valid Net? (10 minutes)

Challenge students who finish early to find a second valid net pattern — a different arrangement of 6 squares that also folds into a cube. Students who find one should draw it, cut it, and verify.

For the class debrief, ask: did anyone find a second net? A third? Point out that there are 11 valid nets for a cube — all different arrangements, all folding into the same shape.

✏️ **JOURNAL PROMPT**

- Draw your net in your journal and label all 6 faces.
- Describe what happened when you folded it: did it work on the first try? If not, what did you change?
- If you only had 5 squares instead of 6 in your net, what would happen when you tried to fold it into a cube?

## ACTIVITY 3
### Nets of Multi-Cube Structures
*Essential Question: How does joining cubes change the net?*

TIME
**~50 min**

Students now work with structures of 2 or more cubes placed side by side. The challenge: when cubes are joined, some faces disappear — they become internal faces that are no longer part of the surface. Students must figure out how many exposed faces remain and why.

### Part 1 — Predict: How Many Squares? (15 minutes)

Ask students to place 2 small cubes side by side (touching along one face). Then ask:

*"If you unfolded this 2-cube structure into a net, how many squares would the net have?"*

Let students make predictions and discuss with a partner before revealing the answer. Most will say 12 (6 faces × 2 cubes). Guide them to see that the two faces where the cubes touch are internal — they are no longer part of the outside surface. So the net has 10 squares.

**TEACHER NOTES**

**Key idea:** When two cubes join, each cube loses 1 exposed face where they touch — so 2 faces disappear from the total. Two separate cubes: 12 exposed faces. Two joined cubes: 12 − 2 = 10 exposed faces.

Many students find this surprising. Let the prediction error do the teaching — the moment of “wait, that’s not 12?” is more powerful than being told the answer.

### Part 2 — Draw and Count: Exposed vs. Internal Faces (20 minutes)

Students draw the net of their 2-cube structure on graph paper. Before cutting, they should:

- Count the total squares in their net — it should be 10
- Mark on the physical structure where the two cubes touch — these are the internal faces
- Draw a sketch of the 2 cubes and circle the internal faces. Confirm that removing these 2 faces gets you from 12 to 10

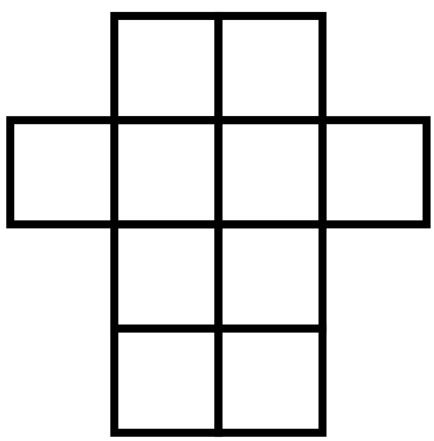


Figure 1. One possible net of a 2-cube structure (10 faces)

**TEACHER NOTES**

**Extension:** What happens with 3 cubes in a row? (6×3 = 18 faces, minus 4 internal faces = 14 exposed). What pattern do students notice? Each cube added in a row adds 4 net squares, not 6.

**For struggling students:** Have them label each face of the physical 2-cube structure (Front, Back, Left, Right, Top, Bottom for each cube). Then physically mark with a sticker the two faces that touch. Count the unmarked faces — that is the net size.

### Part 3 — The Surface Area Connection (15 minutes)

**CONNECTION TO MODULE 4**

The number of squares in a net equals the surface area of the structure — because each square is one 1-inch face, and each 1-inch face has an area of 1 in². The 2-cube structure has a net with 10 squares, so its surface area is 10 in². In Module 4, students will use this face-counting approach systematically to calculate surface area of more complex structures.

This may be the first time students will have seen “surface area” used explicitly. Introduce the term and write it on the board, but do not pressure mastery yet — the full treatment comes in Module 4.

Ask students to apply this idea to their 2-cube structure:

- How many squares are in your net?
- If each square represents one 1-inch × 1-inch face, what is the surface area of your structure in square inches?
- Does the surface area change if you move the second cube from side-by-side to stacked on top? Why or why not?

✏️ **JOURNAL PROMPT**

- Draw the net of your 2-cube structure in your journal. Label every face.
- How many faces does your structure have on the outside? How do you know you haven't missed any?
- What is the surface area of your structure? How did you figure it out?

## Looking Ahead — Module 3

In this module, students discovered that a net must include all exposed faces — and that the number of squares in a net tells you the surface area of the 3D object. Module 3 builds on the same insight from a different angle: instead of unfolding a 3D object, engineers show it using three separate 2D views (top, front, and right side). Just as a net must include every face to be complete, a 3-view drawing must show every dimension to be unambiguous.

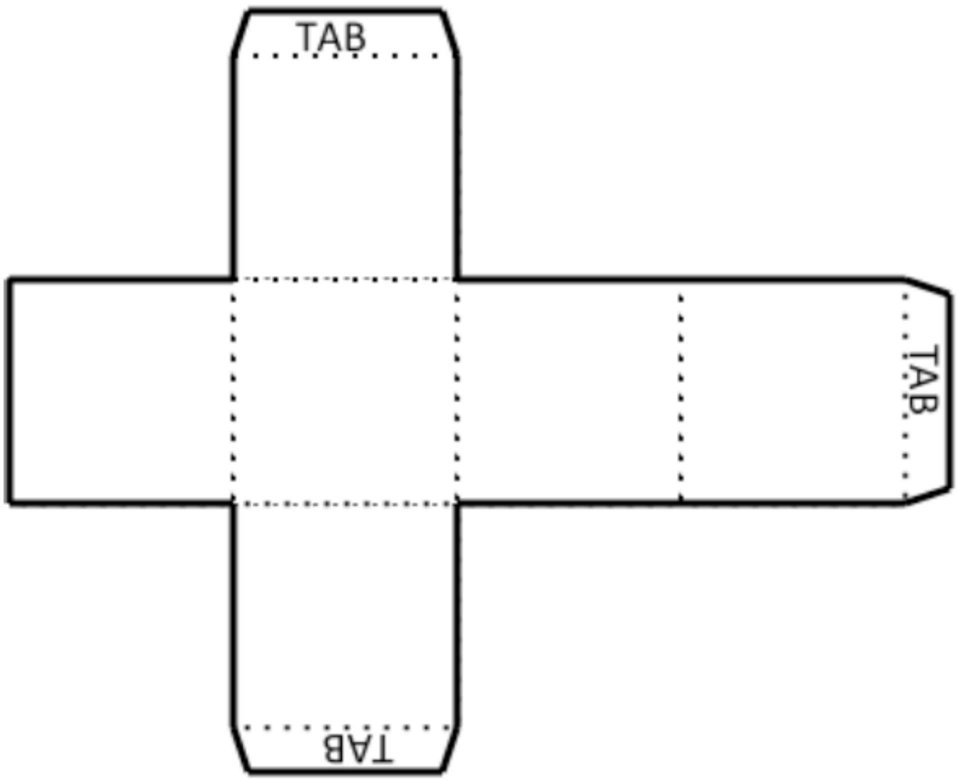
The vocabulary (face, edge, vertex, exposed face) and spatial reasoning habits from Modules 1 and 2 carry directly into Module 3. Students who can identify all the faces of a cube structure — and understand why each face matters — will find the 3-view drawing convention intuitive rather than arbitrary.

# Companion Handouts

# 3-CUBE NET

## Handout 1 — 3-Cube Net Worksheet

Name______________________ Date___________ Student Number___________




Can you come up with a different net for a cube? Draw it and cut it out below.

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