Game On!

English/Language Arts, Grades 6-10

SCALE K-12

SCalable Asymmetric Lifecycle Engagement

PURDUE UNIVERSITY | INSPIRE Research Institute for Pre-College Engineering

INDIANA UNIVERSITY
SCHOOL OF EDUCATION
Bloomington

ROI
REGIONAL OPPORTUNITY INITIATIVES

Cover Information

Unit Title: Game On!
Grade Level Range: 6th – 10th English/Language Arts

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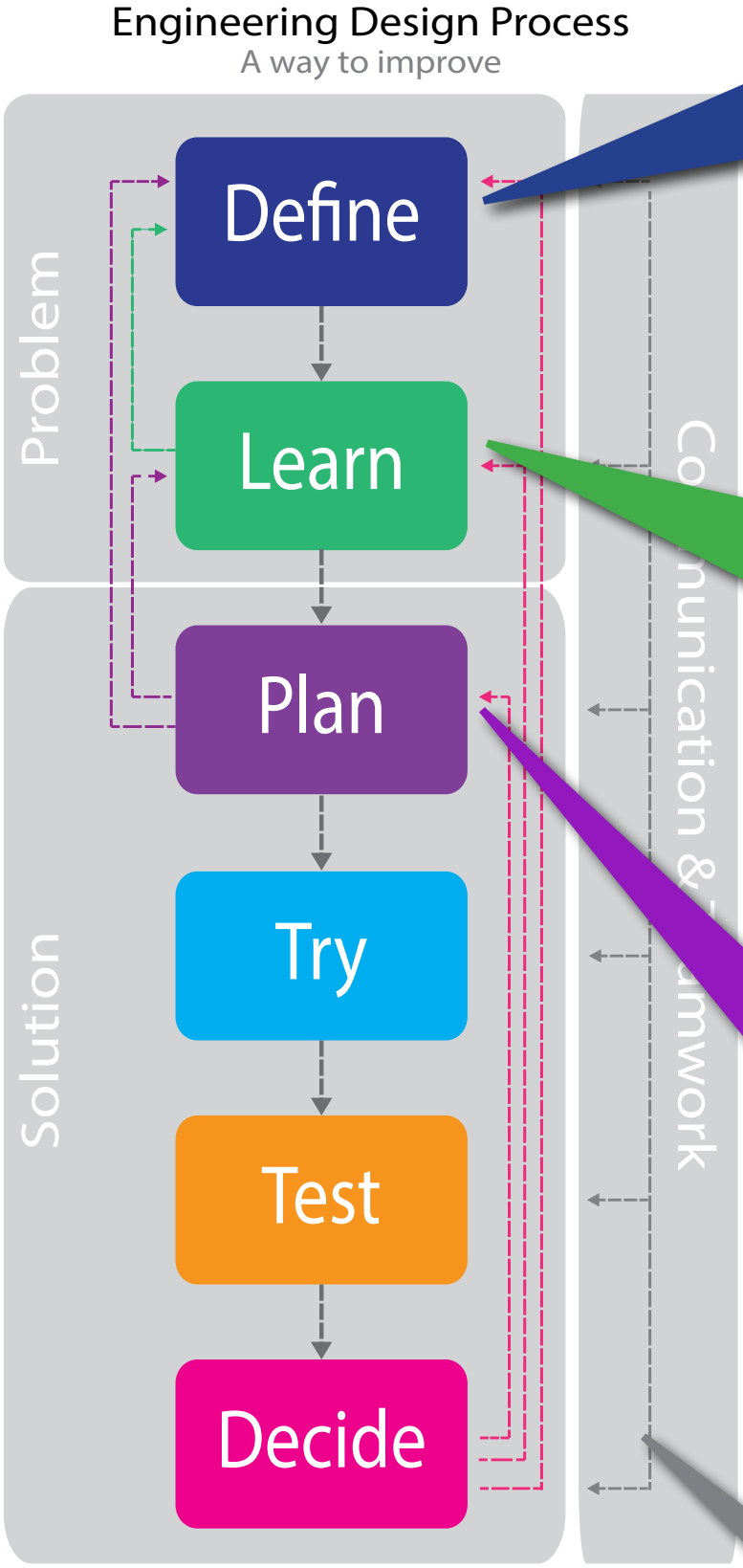
Overview: Engineering Design Process



DEFINE THE PROBLEM

- Who is the **client**?
- What does the client need?
- Why does the client need it?
- Who is the **end user**?
- Why might the end user want it?
- What are the **criteria** (requirements)and **constraints** (limits) of the solution?

Problem Scoping:
WHO needs **WHAT** because **WHY**

LEARN ABOUT THE PROBLEM

- What kind of background knowledge is needed?
  - What science/math knowledge will be needed?
  - What materials will be needed?
- What has already been done to solve the problem?
- What products fill a similar need?
- How should we measure success and improvement?

PLAN A SOLUTION

- Continue to specify the criteria/ constraints
- Generate ideas of possible solutions
- Develop multiple solution paths
- Consider **constraints, criteria**, and **trade-offs** (criteria that compete with one another)
- Choose a solution to try
- Develop plans (blueprints, schematics, cost sheets, storyboards, notebook pages, etc.)

COMMUNICATION

- Communicate the solution clearly and make sure it is easily understandable
- Use **evidence** to support why the client should use your solution

Overview: Engineering Design Process

TRY A SOLUTION

- Put the plan into action
- Consider risks and how to optimize work
- Use criteria/constraints and consider trade-offs from the problem/plan to build a **prototype** (a testable representation of a solution), **model**, or **product**

TEST A SOLUTION

- Consider testable questions or hypotheses
- Develop experiments or rubrics to determine if the solution is meeting the stated criteria, constraints, and needs
- Collect and analyze data

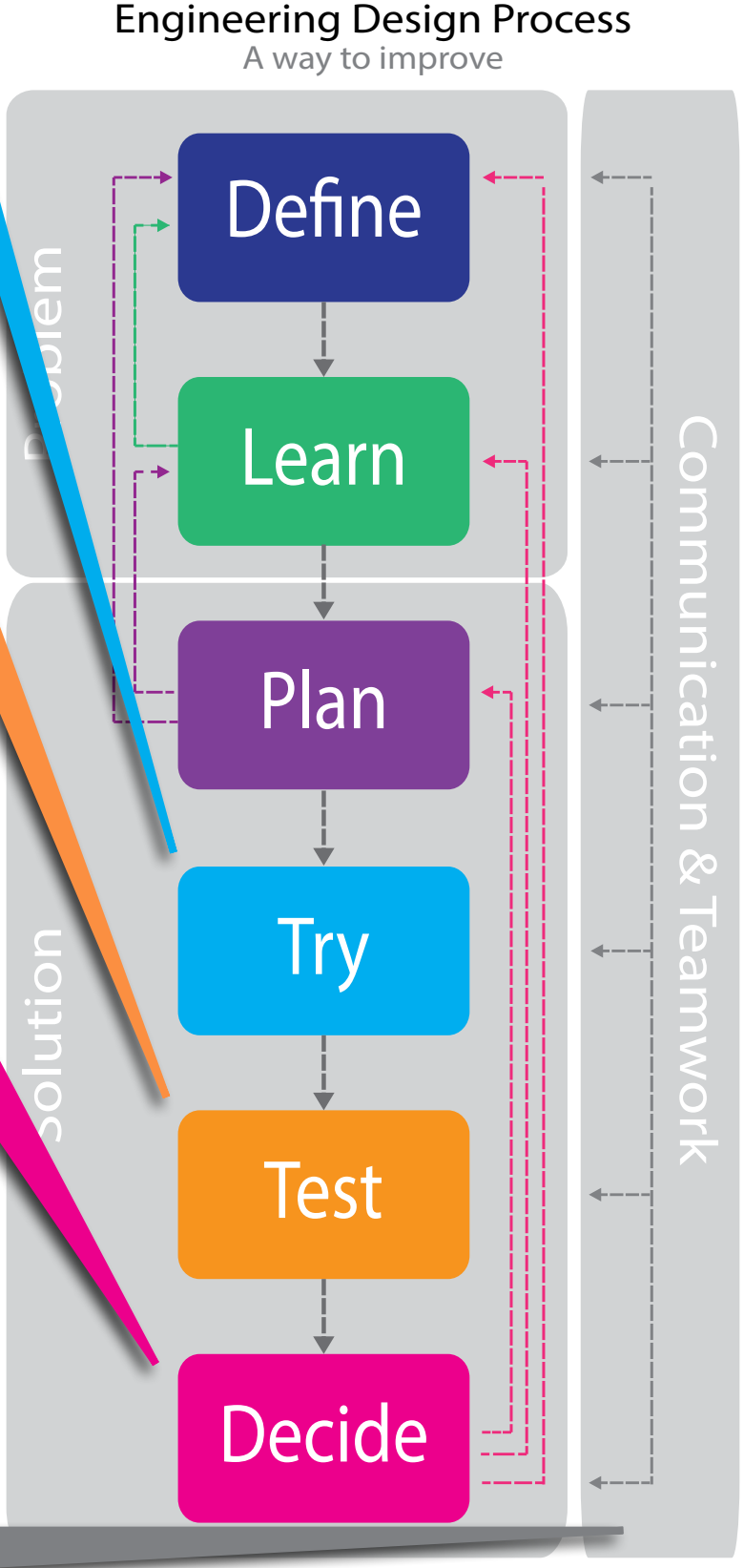
DECIDE IF THE SOLUTION IS GOOD ENOUGH

- Are users able to use the design to help with the problem?
- Does the design meet the criteria and constraints?
- How could the design be improved based on test results and feedback from the client/user?

Iterative nature of design: Always consider which step should be next!

TEAMWORK

- Discuss in teams how the solution meets the criteria and needs of the client
- Consider different viewpoints from each teammate



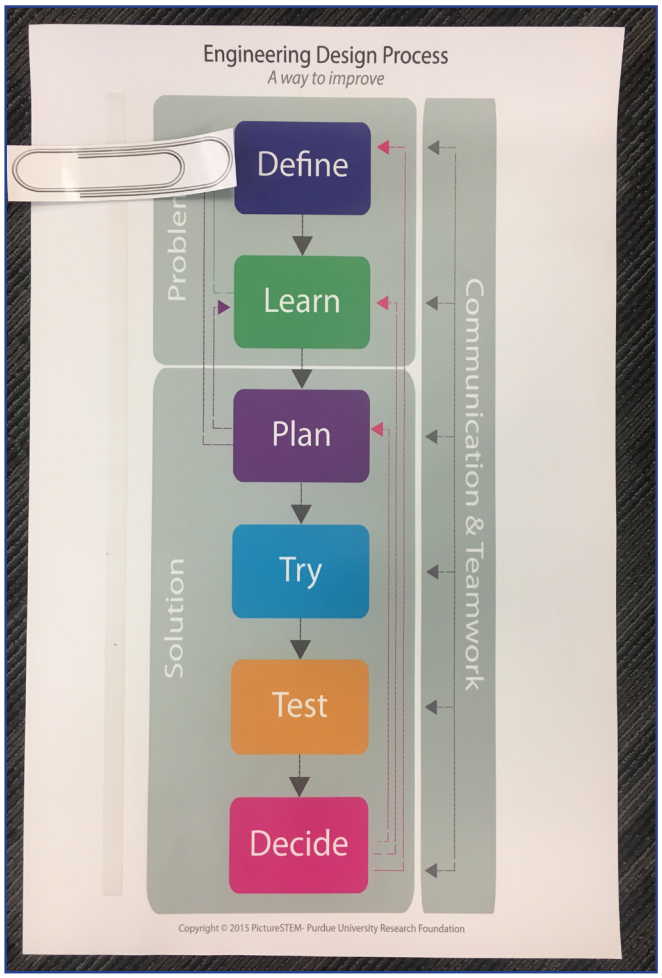
Overview: How to make EDP sliders

How to create the poster

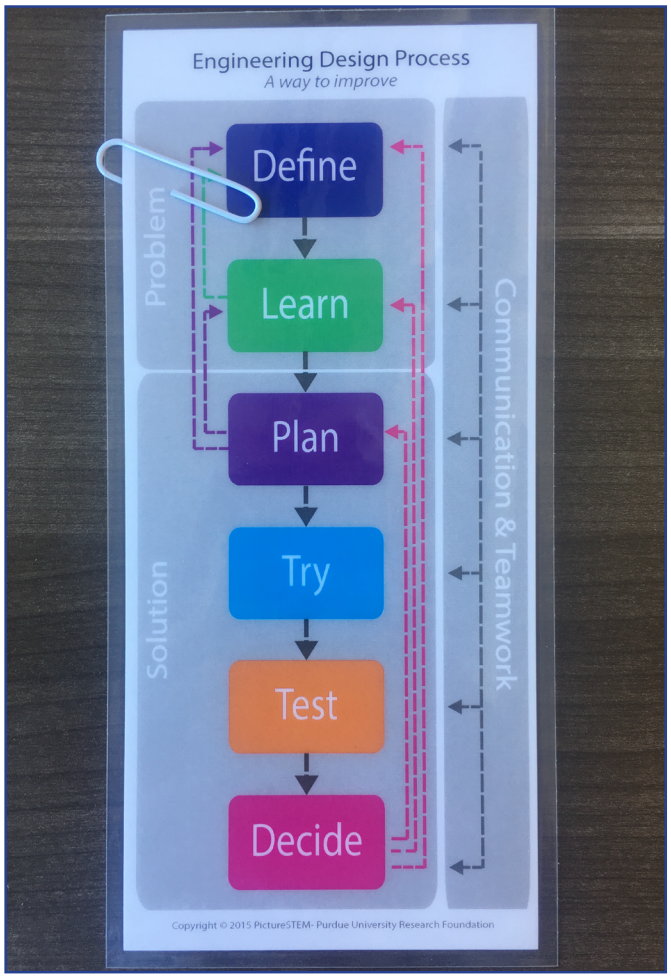
1. Download the high-quality PictureSTEM Slider Poster and the paper clip images from PictureSTEM.org.
2. Print the poster and the paper clip on poster-sized paper and cut to size. High-gloss or semi-gloss paper is the best choice.
3. Use self-sticking Velcro on the back of the paper clip and down the side of the poster so that the paper clip can be placed to point at all 6 sections of the slider.

How to create individual sliders

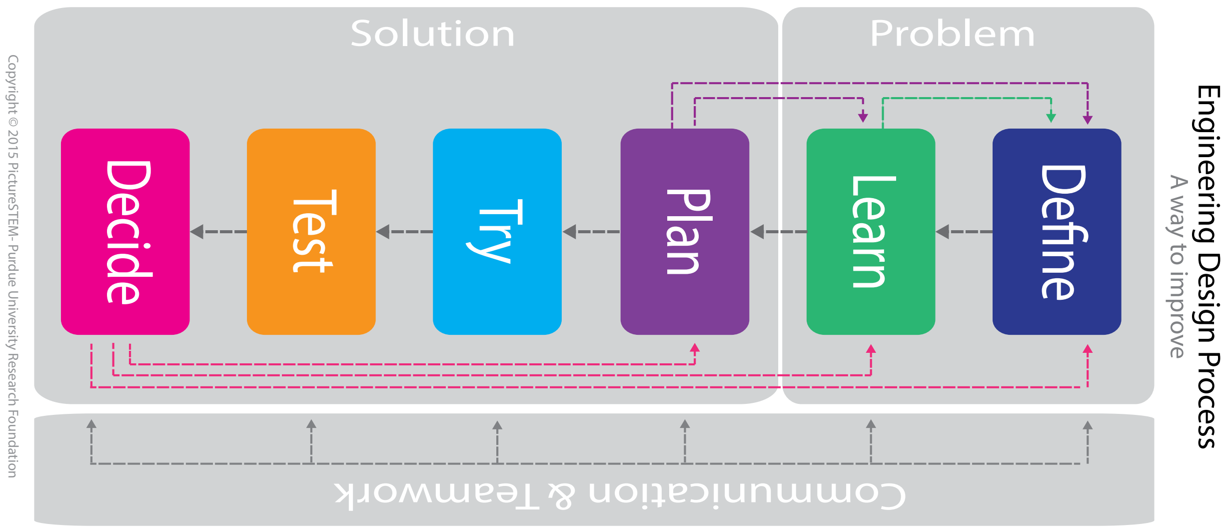
1. Print the sliders on the opposite page - enough for one slider per student in your class.
2. Cut the sliders apart.
3. Laminate the sliders individually.
4. Use a jumbo paper clip as the pointer for each slider.



Poster



Individual slider


Engineering Design Process
A way to improve
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Solution
Define
Learn
Plan
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Communication & Teamwork
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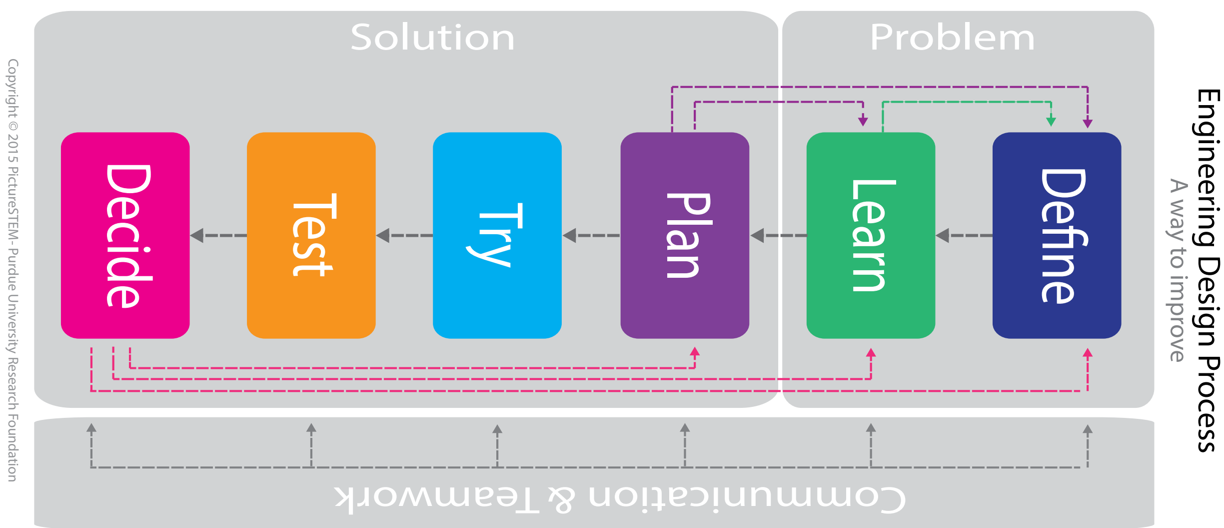
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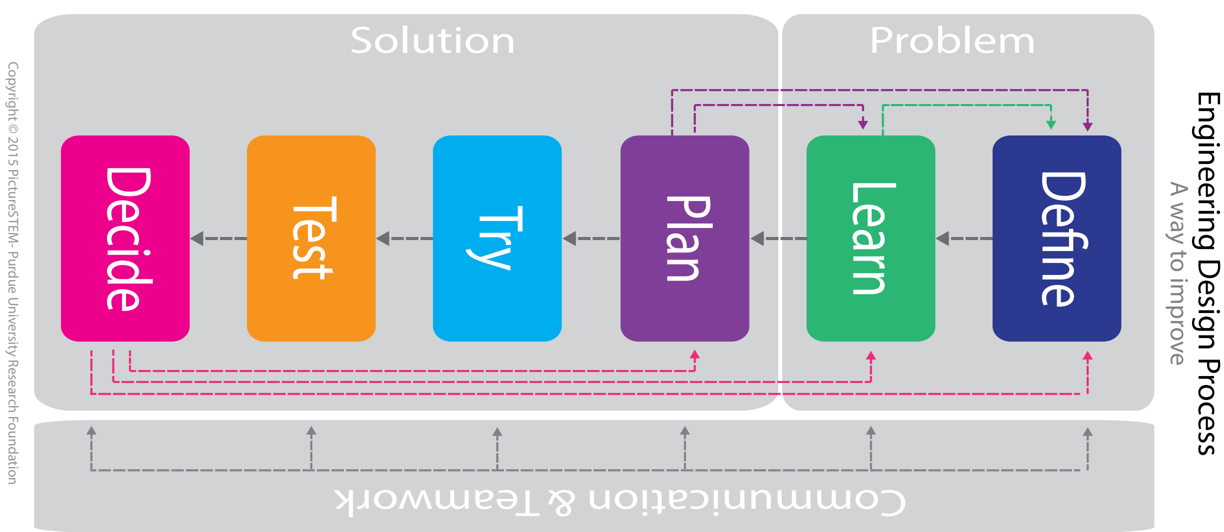
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Unit Overview

Grade Levels: 6th – 10th English/Language Arts

Approximate Time Needed to Complete Unit: 2 – 3 Weeks

Unit Summary:

In this unit, students learn that GEM is looking to revive interest in board games and lessen screen time in students and families. They are planning to do this through adding micro:bit technology into board games that the students create. Students will learn about informative writing, sequencing, and code writing as they plan their instructional manual and prepare an argumentative presentation to the client about their board game. Students will use the Engineering Design Process and play test other team's games, and then redesign and present their final prototypes after receiving feedback from peers and their teacher justifying their design choices. Students will use the writing process to hone their instructions for the game. Students will end the unit by presenting their game design to the client.

Subject Connections:

Technology Connections	Engineering Connections	Writing Connections
Microcontrollers, coding	Game design	Informative writing, argumentative writing, logical flow

Unit Standards:

[Insert standards]

Unit Overview

Lesson Summaries

Lesson 1: Unboxing
Students will be introduced to the engineering design process, microelectronics and game development by the client. Students will learn about the engineering design challenge by annotating the client letter. Videos about screen time and careers in the game design field will be used to provide background information.

Lesson 2: Before You Play…
Students will be introduced to informative writing and its core concepts (clear information, organization, reasoning, etc.). Part 1: Students will participate in a robot activity where one student is given a task and must write (or sequence) directions for a partner. The partner has to follow the directions exactly. The class will engage in a discussion to debrief on the activity. Part 2: Students will be introduced to different informative styles and conventions. Students will examine and label informative writing samples.

Lesson 3: Do Not Pass Go
Students will read and annotate an article about kids' screentime usage. Students will complete an informative writing assignment. There will be 2 options: students may write in paragraph form or practice procedural sequence writing. This writing will inform writing instruction and support throughout the unit. Students will read a client memo introducing the 5 divisions of the game board company.

Lesson 4: Set Up the Board
Students will examine a set of instructions that are poorly written. They will make improvements to these instructions in the Make-it-Better Activity. Students will read another client memo, introducing constraints (3 gameboard templates), criteria, and the need to learn about micro:bits. Students will be given 3 basic game templates as a starting point to design their games. Students will individually brainstorm and complete the notebook prompt for what game concept they would like to do. They will meet in groups to decide and storyboard their game. Students will use evidence-based reasoning to justify their design decisions.

Lesson 5: Side Quest
Students will be introduced to coding and micro:bits through 3 different styles of activities: unplugged (which involves putting together code (Block or Python) puzzle pieces), embodied (which involves students having specific jobs/tasks and they are to put themselves in order to get the correct output), and plugged (which involves coding the micro:bit to fit within the constraints and criteria of the engineering design challenge).

Lesson 6: Multiplayer Mode
Students will compose their instruction manual draft and build their game prototype. Students will test their own games before design review.

Lesson 7: Draw a Card
Students will playtest other groups games and evaluate the quality of other games using rubric that focuses on context, constraints, and playability. Then, students will redesign their games and instructions after receiving feedback from their peers. Students will use evidence-based reasoning to justify their redesign decisions. Students will receive another client memo about presentation requirements.

Lesson 8: Final Boss
Students will argumentatively present their final design to the client. Students will demonstrate evidence-based reasoning to justify their design choices. Students will submit an individual unit reflection.

Master Materials List

	Unit Materials	Lessons Where Material is Used
Per Classroom	EDP Poster	1, 2, 3, 4, 5, 6, 7, 8
	Construction paper	6, 7
	Pipe cleaners	6, 7
	String	6, 7
	Popsicle sticks	6, 7
	(2) Glue Bottles	6, 7
	(2) Glue Sticks	6, 7
	(2) tape	6, 7
	(optional) materials from home	6, 7
Per Group (assume 3 students per group)	Box of colorful pens	1, 2, 3, 4, 6, 7
	(2) graham crackers (2 students per group)	2
	(1) marshmallow (2 students per group)	2
	(1) chocolate square (2 students per group)	2
	(1) paper plate (2 students per group)	2
	Micro:bit kit [micro:bit, battery case, (2) AA batteries, USB to micro-USB cord]	5, 6, 7, 8
	Foldable gameboard base	6, 7
Per Student	EDP slider w/ jumbo paperclip	1, 2, 3, 4, 5, 6, 7, 8
	Laptop or equivalent device	1, 2, 3, 4, 5, 6, 7, 8
	Engineering notebook	1, 2, 3, 4, 5, 6, 7, 8

Unit Planner

Lesson	Time Needed	Objectives (Students will be able to …)	Duplication Masters
1. Unboxing: Design Process and Problem Scoping	Two 45-minute classes	• Identify the problem from a client. • Identify background knowledge needed to develop a solution. • Define criteria and constraints. • Explain the relevance of and practice textual annotation.	1.A Content Pre-Assessment 1.B Problem Scoping Prompts 1.C Client Letter 1.D Problem Scoping Example
2. Before You Play: Informational Writing Activity	Two 45-minute classes	• Identify different informative writing styles and conventions. • Explain information presented in age-appropriate informative texts. • Reflect on how the content information connects to activities complete in class.	2.A Client Memo 1 2.B Robot Activity Guidelines 2.C Informative Writing Organizer 2.D Informative Writing Samples 2.E Informative Writing Organizer Key
3. Do Not Pass Go: Informational Writing Practice	One 45-minute class	• Annotate age-appropriate article using rubric. • Use prior knowledge of informative writing to write and appropriate response to the prompt. • Identify additional criteria and constraints from the client.	3.A Screen Usage Articles 3.B Screen Usage Questions and Rubric 3.C Client Memo 2
4. Set Up the Board: Game Design and Storyboarding	Two/three 45-minute classes	• Identify information gaps and rewrite poorly written instructions. • Annotate and identify criteria and constraints in a client letter. • Complete brainstorming and notebook prompt for game concept • Communicate in groups and complete a game storyboard using evidence-based reasoning.	4.A Make-It-Better Activity 4.B Client Memo 3 4.C Gameboard Templates 4.D Planning Prompts 4.E Evidence-Based Reasoning Graphic 4.F EBR Instructions 4.G EBR Example

Unit Planner

Lesson	Time Needed	Objectives (Students will be able to …)	Duplication Masters
5. Side Quest: Sequencing, Coding, and Micro:bits	Two 45-minute classes	• Explore sequencing through multi-modal representations. • Code a micro:bit using block-based coding.	5.A Unplugged Activity 5.B Coding Information 5.C Client Memo 4
6. Multiplayer Mode: Manual Draft and Prototype Build	Two 45-minute classes	• Evaluate their role in academically-minded teams. • Craft clear instructions following the writing process. • Collaboratively construct a game prototype. • Evaluate their game instructions through testing.	6.A Gameboard Templates 6.B Testing Reflection 1
7. Draw a Card: Game Testing and Redesign	Two 45-minute classes	• Evaluate other teams' designs using a rubric. • Redesign their solution to the engineering challenge using evidence and feedback from other groups. • Create a publishable quality version of their instructions for the client.	7.A Evaluation Rubric 7.B Testing Reflection 2 7.C Redesign Prompts 7.D Client Memo 5 7.E Client Communication Guidelines
8. Final Boss: Client Communication	Two 45-minute classes	• Compose an argumentative presentation. • Reflect on engineering, writing processes, and learning.	8.A Presentation Evaluation 8.B Content Post-Assessment 8.C Content Post-Assessment Key 8.D Client Memo 6

LESSON ONE:

Lesson Objectives
Students will be able to:
- Identify the problem from a client.
- Identify background knowledge needed to develop a solution.
- Define criteria and constraints.
- Explain the relevance of and practice textual annotation.

Time Required
Two 45-minute lessons

Materials
Per classroom:
- EDP Poster

Per group (3 per group):
- Box of colorful pens

Per student:
- EDP slider w/ jumbo paperclip
- Laptop or equivalent device
- Engineering notebook

Standards Addressed
IAS Integrated STEM
- MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Key Terms
client, engineering design process (EDP), criteria, constraints, microelectronics, annotation

Lesson Summary
Students will be introduced to the engineering design process, microelectronics and game development by the client. Students will learn about the engineering design challenge by annotating the client letter. Videos about screen time and careers in the game design field will be used to provide background information.

Background
Teacher Background
Teamwork: Students will be grouped according to their interests in one of five design target pathways (see 3.C Client Memo 2). Students should be grouped strategically and may or may not be assigned jobs within their group. When forming student groups, consider academic, language, and social needs. In place of strategic grouping, a random grouping can be substituted. Students will work in these groups, or "teams" throughout the unit. Effective teamwork is essential in this unit as well as in engineering in general; however, this unit does not provide specific support to develop those skills. If your students do not have experience with teamwork, it is highly recommended that you do some targeted team-building activities prior to beginning this unit. The teams will each specialize in a specific context related to their interests. This is explained further in the client memo in lesson 3. Until then, any groups they may work in can be random.

Engineering Design Process:
NOTE: If students are familiar with the engineering design process (EDP) before beginning the unit, the teacher can skip this (EDP) introduction.

The engineering design process (EDP) is an iterative, systematic process used to guide the development of solutions to engineering problems. There is no single engineering design process, just like there is no one scientific method. However, the various engineering design processes have similar components. The engineering design process (EDP) involves understanding the problem, learning background information necessary to solve the problem, planning, trying, testing the solution, making changes based on the tests, and communicating ideas. Students will use an engineering design process slider throughout the unit to help them understand where they are in the design process. For more information about the steps of the engineering design process presented in this unit, see the front matter section about it.

Some common misconceptions:
Related to engineering

- Engineers do not have to learn anything new when they are working on a project. **In reality:** Engineers need to continually learn throughout their lives.
- Engineers come up with solutions that are just "good enough" and don't take risks. **In reality:** Engineers strive to create the best solution possible through optimization. It is normal to experience failure when solving engineering problems.
- Engineers work alone to solve a design problem. **In reality:** Engineers collaborate with folks in different disciplines and fields to best solve a problem. Engineering problems often require a wide range of content knowledge.

Related to the EDP

- The engineering design process is linear, and you never need to go back to previous phases. **In reality:** The EDP is a cyclical process that requires many iterations.
- Once the project is done it is considered complete and not revisited. **In reality:** The engineering design process is never really "done," it is revisited so engineers can improve projects and make changes.

Criteria and Constraints: One of the key elements of the engineering design process, and often a confusing part for students is the criteria and constraints. Criteria are the features of the solution that the client wants, while constraints are the limiting factors that the design must adhere by. Another way of thinking about the criteria are that they are anything the client and the engineers will use to judge the quality of a solution. Constraints are a specific type of criteria; they are those criteria that limit design possibilities, or the ways that the problem can be solved. If constraints are not met, the design solution is by default not a viable solution to the problem. Go over these definitions with your students before asking them to identify criteria and constrains from the client letter.

Problem Scoping: In this lesson, students will be in the Problem Scoping section of the engineering design process, specifically on the define the problem step. Define the problem and learn about the problem combine to make Problem Scoping. In this stage, students will be first introduced to the engineering problem through a client letter and then be given a chance to ask questions to the client and receive more information about the problem. The problem statements given in the client memos purposefully do not provide

Assessment

Pre-Activity Assessment
Use the 1.A Content Pre-Assessment to evaluate students' prior knowledge in terms of the unit learning goals.

Activity Embedded Assessment
Listen to whole class and small group discussion when students are problem scoping. Use the 1.B Problem Scoping Prompts to determine the extent to which students are identifying the client's problem.

Post-Activity Assessment
Review students' engineering notebooks to find out how they engaged with the Define phase of the engineering design process.

Duplication Masters

- 1.A Content Pre-Assessment
- 1.B Problem Scoping Prompts
- 1.C Client Letter

Educator Resources

- 1.D Problem Scoping Example

all the information necessary to solve the problem. Students are tasked with generating questions about the problem to try to fill in this missing information. Based on all information from the client, students will then define the problem in terms of: what the problem is and why it is important, who are the client and end users, what are the criteria and constraints, and what other information they may need to learn about in order to solve the problem. This process of generating ideas and questions for the client is an important skill on its own both in engineering and in other fields, but it also helps to ensure that the students fully understand the problem and their task in the engineering design challenge.

Solution Generation: The Solution Generation section of the engineering design process includes plan the solution, try out the plan of the solution, test the solution, and decide whether the solution is good enough. When engineers are generating solutions, they will use iteration as a means to continually improve their solution, reflect back on the problem definition and what they have learned about the problem, and consider criteria, constraints, and trade-offs. Trade-offs involve having to make compromises about which criteria to emphasize because they compete with one another in terms of making a solution effective. For example, cost could be a trade-off to durability.

Engineering Notebook: Throughout the unit students will be recording information in an engineering notebook. You may want to have your students write in their notebooks in two different colors – one for thoughts and prompts that are individual and one for thoughts and prompts that they discuss in their teams. This well help you assess the students' ideas as well as help them recognize their own contributions and ideas. You also may want to have students complete a Notebook Cover and start a Table of Contents page. You may choose to have students tape/glue copies of the notebook prompts and/or the duplication masters into their notebooks or they can copy down a projected version of the prompts.

Vocabulary: Students will be introduced to many new science and engineering vocabulary terms throughout the unit. It may be helpful to create a vocabulary section in their notebook with term definitions and memory clues. Additionally, the class could maintain a word wall or anchor chart.

Before the Activity

- Assemble the Engineering Design Process Sliders and post the EDP Poster in the classroom (see the front matter for how to assemble them). Make sure you and your students can refer to the EDP sliders and/or poster throughout the unit.
- Download the links to videos given in the 1.C Client Letter (also shown here) and make sure they will play in your classroom.
  - Manufacturing process of board games: https://www.youtube.com/watch?app=desktop&v=WOcPKds47bo
  - Example of integration of analog and digital game components: https://www.youtube.com/watch?v=r2fsgTOms8U
- Make sure students have access to this article in case they are interested in learning more about the process of game design: https://www.timeforkids.com/g34/your-hot-job-game-on-g3/
- Print and make copies of the following duplication masters in the labeled amounts:
  - (1 per student) 1.A Content Pre-Assessment, 1.B Problem Scoping Prompts, 1.C Client Letter

Classroom Instruction

Introduction

1. **Assess prior knowledge.** Pass out the 1.A Content Pre-Assessment. Give students time to complete the open-ended questions about writing, engineering, and microelectronics. Make sure to tell students that the purpose of this activity is simply to assess any prior knowledge, so it is okay to not know the answers.
2. **Introduce the unit.** Tell students what they are going to be learning about in the engineering unit. **Say:** *In this unit, we will be working on an engineering project that reuses microelectronics from a company to design board games that bridge the gap between digital games and physical board games.* Lead a discussion in the class in which students are able to share their prior knowledge on the topics of informative writing, argumentative writing, engineering, microelectronics, and coding. Prompts may include the following: *What do engineers do? What kinds of industries do engineers work in? What are some examples of microelectronics? How have electronics been used in board games?*

3. **Introduce the Engineering Design Notebooks. Say:** *Engineers use notebooks to document their design process and keep notes. We will also be using Engineering Notebooks throughout our engineering challenge. Each day you'll use the notebooks to take notes on what you are learning. In addition, there are questions that you'll be asked to answer. Sometimes you'll answer the questions first on your own, then in your teams. Each day, turn in your engineering notebooks before you leave class.*

Activity

4. **Discuss engineers and engineering.** Introduce section one of the 1.B Problem Scoping Prompts. Direct students to respond to these prompts individually. Make sure to let them know that it is okay if they do not know very much about engineers or engineering - just have them answer these questions to the best of their ability.
5. **Introduce the Engineering Design Process (EDP). Say:** *Engineers use an engineering design process along with mathematics, science, and creativity to understand a problem and come up with a solution.* Pass out the sliders and outline each step of the engineering design process. The amount of time this will take will vary dependent on your students' familiarity with engineering. There is a detailed description of the EDP Slider in the front matter of the unit. **Ask:** *Based on what we have discussed so far, where do you think we are in the engineering design process?* (Define)
6. **Introduce the problem. Ask:** *How often do you spend time looking at screens on an average day?* Allow students to discuss the impacts of extensive screentime. Encourage whole class discussion about the pros and cons of electronics like phones, laptops, etc.
7. **Read the client letter.** Distribute the 1.C Client Letter to students and have them individually read through the letter once. Encourage students to take notes throughout the problem scoping phase in their engineering notebooks.
8. **Watch videos from the client.** Show students the videos embedded in the client letter on microelectronics and game design to provide some background context. Encourage students to take notes in their notebooks. After watching the videos discuss how microelectronics showed up in the videos. **Ask:** *How are microelectronics used in the manufacturing of board games?* Let students identify aspects of the process like laser cutting, sensing, and assembly which all require

microelectronic devices.

9. **Identify the problem from the client.** To help students work through the problem scoping phase of the design process, have them use multicolored pens to annotate important information as the reread the client letter.
10. **Identify required information using annotation.** Have students continue to annotate the client letter for important information. It may be helpful for students to use certain colors when marking up the letter and answering the prompts.
11. **Complete problem scoping sections two and three. Say:** *Now use the information you found when annotating the client letter and watching the informational videos to fill out sections two and three of the 1.B Problem Scoping Prompts.* Students can work in groups if they struggle to complete the prompts. After identifying required information in section two, encourage students to highlight/underline the things on their list they already know. They should be able to revisit their list throughout the unit to make sure they are learning what they need to and can add additional questions they have for the client.

Closure

12. **Identify where students are in the engineering design process. Ask:** *In relation to our design challenge, what phase of the engineering design process did we focus on today? How do you know?* Have students move the paper clip on their engineering design process slider to the appropriate spot. **Say:** *We are in the DEFINE stage.*
13. **Review problem scoping. Ask:** *What is the problem our client asked us to solve?* Conduct a review discussion about the engineering challenge. **Ask:** *Why is it important to fully define the problem?* Ex: Students need to understand the root of the problem from the perspective of the client and other stakeholders before attempting a solution.

Name_____ Date_____ Period _____

1.A Content Pre-Assessment

Part 1 Directions: Circle True or False. Explain in your own words how you know the answer. It is okay if you don't know the answers!

True or False	Statement
1. T or F Explain:	*The following sentences use the informative writing style:* Dogs are great pets because they are loyal to their owners. They are also playful and like to have fun.
2. T or F Explain:	You are using **logical flow** in your writing when you use transition words like *first, next,* and *finally.*
3. T or F Explain:	Sequencing is **not** important to coding.
4. T or F Explain:	A good example of informative writing includes **evidence**.
5. T or F Explain:	Micro:bits can be used in your home.
6. T or F Explain:	Argumentative writing and informative writing are the same.
7. T or F Explain:	Evidence-based reasoning is **not** important when designing something.

Name_____ Date_____ Period _____

1.A Content Pre-Assessment

Part 2 Directions: Answer the following questions. You can use drawings or write in the language most comfortable for you if you get stuck. It is okay if you don't know the answers!

8. What does the term, "microelectronics" mean?

9. How are microelectronics used in the field of language arts?

10. What jobs would you be interested in that use microelectronics?

11. Provide one example of how microelectronics is used in that job.

Name_____ Date_____ Period _____

1.B Problem Scoping Prompts

Section 1:

Directions: Please answer the following questions.

1. **What do engineers do?**

2. **How do engineers solve problems?**

Section 2:

Directions: Please answer these questions after hearing about the engineering challenge.

1. **What questions do you want to ask to the client?**

Section 3:

Directions: Please answer these questions after you have been able to ask questions about the challenge.

First, on your own, complete each prompt on your own. Then write your revised answer (if different) to the prompt, based on the discussion with your team. You may use a different color writing utensil to distinguish your answer and how it changed after talking with teammates.

1. **The client is:**

2. **The client's problem is:**

Name_____ Date_____ Period _____

1.B Problem Scoping Prompts

3. **The problem is important to solve because:**

4. **The end-users are:**

5. **An effective solution for the client will meet the following criteria:**

6. **The constraints (or the limits) of the solution are:**

7. **Think about the problem of kids losing interest in board games due to increased screen time usage. In terms of game development, what are at least 2 things you need to learn in order to design a prototype for a board game that incorporates microelectonics? Make sure to consider all important aspects of the problem. Be specific.**

1.C Client Letter

Dear Engineers,

My company, GEM (Games, Electronics, and Motivation) has a problem. We design and manufacture different types of games, but kids are losing interest in our board games. They are spending more time on screens and digital games. We are experiencing a 72% loss in demand for our board games.

Our plan is to incorporate our microelectronic devices into our board games to get kids and families playing again. This will allow us to bridge the gap between electronic games and traditional board games that families and children have loved for many years. We are hoping that we can use your creativity and your new-found knowledge of the engineering design process to create exciting prototypes that can inspire our game designers.

These are links to videos and an article which may be helpful as you start thinking about the process of creating new board games using microelectronics:

- https://www.youtube.com/watch?app=desktop&v=WOcPKds47bo
- https://www.youtube.com/watch?v=r2fsgTOms8U
- https://www.timeforkids.com/g34/your-hot-job-game-on-g3/

As you help us design these new games, keep in mind that our company is also focused on the future of our environment and on our bottom-line. Therefore, we would also like to reuse materials we already have.

Can you help us?

Sincerely,

Rubi Gonzalez

Rubí Gonzalez
Engineering Outreach Coordinator
Games, Electronics, and Motivation (GEM)

1.D Problem Scoping Example

1. **The client is:**

Ex: Rubi Gonzalez

2. **The client's problem is:**

Ex: Kids are losing interest in board games becuase of increased screen time

3. **The problem is important to solve because:**

Ex: The company Rubi works for had a 72% loss in demand for board games

4. **The end-users are:**

Ex: Kids and their families

5. **An effective solution for the client will meet the following criteria:**

Ex: A board game prototype, include a microelectronic device

6. **The constraints (or the limits) of the solution are:**

Ex: Has to reuse materials the company (GEM) already has

7. **Think about the problem of kids losing interest in board games due to increased screen time usage. In terms of game development, what are at least 2 things you need to learn in order to design a prototype for a board game that incorporates microelectonics? Make sure to consider all important aspects of the problem. Be specific.**

LESSON TWO:

Lesson Objectives
Students will be able to:
- Identify different informative writing styles and conventions.
- Explain information presented in age-appropriate informative texts.
- Reflect on how the content information connects to activities completed in class.

Time Required
Two 45-minute lessons

Materials
Per classroom:
- EDP Poster

Per group (2 per group):
- Graham cracker sheet
- Marshmallow
- Chocolate bar
- paper plate
- Box of colorful pens

Per student:
- EDP slider w/ jumbo paperclip
- Laptop or equivalent device
- Engineering notebook

Standards Addressed
IAS English/Language Arts
- 5-6.W.2, 7.W.3.2, 9-10.W.2

Key Terms
Informative writing: Literary nonfiction, expository, argumentative, procedural

Logical flow: Chronological, order of importance/priority, step-by-step, description

Lesson Summary
Students will be introduced to informative writing and its core concepts (clear information, organization, reasoning, etc.). Part 1: Students will participate in a robot activity where one student is given a task and must write (or sequence) directions for a partner. The partner has to follow the directions exactly. The class will engage in a discussion to debrief on the activity. Part 2: Students will be introduced to different informative styles and conventions. Students will examine and label informative writing samples.

Background
Teacher Background
Informative Writing: Informative writing shares information about processes, research, or experiences. This writing is especially important during the design and iteration process. Informative writing requires the author to step outside their assumptions, biases, and opinions about the topic they are focused on. Using a neutral tone, informative writing is used to convey information, not opinions and typically requires citations of reputable source material or research.

Before the Activity
- If you would like an example of an opinion piece to use as a comparison to informative writing, this is an option relevant to the screen time context: https://www.timeforkids.com/g34/share-screen-2/
- Prepare the following s'mores materials for each group of 2 students on a paper plate
  - (1) Chocolate bar - wrapped
  - (1) Graham crcker sheet - whole
  - (1) Marshmallow
- Print and make copies of the following duplication masters in the labeled amounts:
  - (Per student) 2.A Client Memo 1, 2.C Informative Writing Organizer, 2.D Informative Writing Samples
  - (Per group) 2.B Robot Activity Guidelines

Classroom Instruction
Introduction
1. **Reintroduce the engineering problem. Ask:** *What is our engineering design problem?* Students may need to revisit the original client letter to remind themselves of the engineering

design challenge.

2. **Identify where they are in the engineering design process (Learn). Say:** *So far, we have defined the problem with help from our client.* Point out the "Define" block on the engineering design process and have students look at their Engineering Design Process sliders. **Say:** *Before we can start designing solutions, we need more information.* **Ask:** *What step of the engineering design process are we in now?* Students should identify that they are in the "Learn" phase.
3. **Identify what students need to learn about. Say:** *In the previous lesson, you brainstormed what we need to learn about.* **Ask:** *What were some of those concepts that we need to learn?* Remind students to refer to their notes from the previous lesson. **Say:** *To learn the writing concepts we need to use to solve the client's problem, we first need to review the different types of writing.*

Activity

4. **Connect to prior knowledge. Ask:** *What are some types of writing you are familiar with?* Have a brief discussion with students about narrative, informative, and argumentative writing.
5. **Introduce robot activity. Say:** *We are going to do an activity to understand more about informative writing. To do this you will work in groups of two where one of you will pretend to be a robot and the other will come up with instructions the robot has to follow.* Describe how a robot operates. **Say:** *Similar to computers, robots can only use the input that they are given. They cannot interpret information if we don't provide clear, direct inputs.* Talk to the students about how easy it is to miss a critical step or misinterpret how a computer would process instructions.
6. **Place students into groups of two. I**n their small groups, assign one student to be the robot and the other to be the one writing instructions. Hand out the 2.B Robot Activity Guidelines making sure that the student gets the correct version of the guidelines. One page is instructions for the "robot" the other page is for the "writer".
7. **Complete robot activity. Say:** *Follow the rules listed on the 2.B Robot Activity Guidelines. You will have different responsibilities depending on your assigned role. Only read the instructions for your assigned role.* Give students a chance to read the rules then distribute the s'more materials. Each group needs enough materials to make one s'more on a paper plate.
8. **Debrief with students.** Discuss the challenges of the activity.
9. **Introduce informative writing content.** Handout the 2.C

Assessment

Pre-Activity Assessment

Listen to the discussion students have when revisiting the engineering challenge to identify what students recall about the client's problem.

Activity Embedded Assessment

Listen to student interaction during the robot activity to see if they begin to understand core aspects of informative writing (logical flow etc.)

Post-Activity Assessment

Evaluate the graphic organizers students completed during the lesson to find gaps in their knowledge of informative writing.

Duplication Masters

- 2.A Client Memo 1
- 2.B Robot Activity Guidelines
- 2.C Informative Writing Organizer
- 2.D Informative Writing Samples

Educator Resources

- 2.E Informative Writing Organizer Key

Informative Writing Organizer or have students create a table in their engineering notebooks. Discuss genres and variations (typical structure vs. structure of process) of informative writing. As you introduce the styles and conventions, have students fill out the first column of the organizer. (Optional) This can be done as a jigsaw activity where students work in groups to identify information for just one key component of informative writing.

10. **Individual exploration.** Now that they have been introduced to informative writing, have students do an internet search to fill in any gaps they have in the first column, so they have a description for each of the key components. They can work in groups and discuss what they've found if there is time.
11. **Explain and discuss information. Ask:** *What did you learn about informative writing in your search?* Discuss the components of informative writing using the 2.E Informative Writing Organizer Key as a guide.
12. **Complete writing sample activity.** Hand out the 2.D Informative Writing Samples to each student. Say: These are all examples of informative writing so you can see the different application of the components you just described. As you read through these sample writing pieces, use your colored pens or markers to identify the components of informative writing embedded in the samples.
13. **Add to graphic organizer.**

Closure

14. **Connect the activity to the engineering design challenge.**

2.A Client Memo 1

Dear Engineers,

I'm so excited that you have accepted the challenge of creating this board game that uses microelectronics. I wanted to walk you through a few of the pieces of this process. One of the critical parts of this project is communicating with our game designers and creating clear instructions for our clients who will be playing these amazing new games.

So, the next few days, I want your teams to focus on learning informational writing. You will be tasked with thinking through what good instructions really look like. Think about places your instructions could confuse a new player. Work on finding the perfect balance between clear gameplay and exciting word choice that builds the anticipation to dive into the game. At the same time, you will develop the ability to clearly communicate with our game design teams, too.

I cannot wait to see what you create.

Sincerely,

Rubi Gonzalez

Rubí Gonzalez
Engineering Outreach Coordinator
Games, Electronics, and Motivation (GEM)

2.B Robot Activity Guidelines

Instructions for writer
Your job is to create a set of directions the robot can read to make a s'more. If you do not have access to a microwave, you can stop writing when your directions end in an assembled s'more. The robot will be reading your directions like a computer carrying out lines of code. Make sure you only write one task per line in your directions below. Use scratch paper if you run out of room. When you are done writing, pass your directions to the robot so they can complete their job.

Safety note:
If you are using a microwave for this activity, make sure the whole s'more is not in the microwave for more than 20 seconds or the marshmallow will explode. You will need to include this information in your directions to the robot.

Directions:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____

2.B Robot Activity Guidelines

Instructions for robot
You will be interpreting the writer's directions word for word like a computer or robot would. Even though you already know how to make a s'more correctly, you can only follow the directions on paper as they were written. You job doesn't start until the writer finishes drafting their directions.

Once the writer is done:
Work through the list of directions given by the writer one at a time. Make sure to only follow exactly what is written. Read the first line of directions then carry out the task. *For example: if the first line is "break the chocolate bar into pieces", you should break the unwrapped bar into pieces instead of opening the wrapper first since the directions did not specify to unwrap the chocolate bar.* Continue to read then complete each line of directions.

2.B Robot Activity Guidelines (Alternative)

Instructions for writer
Your job is to create a set of directions the robot can read to make a s'more. If you do not have access to a microwave, you can stop writing when your directions end in an assembled s'more. There are extra lines in case you want to add more details. Mark the transition words you used at the bottom of the page. When you are done writing, pass your directions to the robot so they can complete their job.

Directions:

First, take the _____.

_____

Then, put the _____ on the _____.

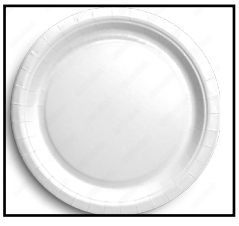
Next, put the _____ on the _____.

_____

After that, put the _____ on the _____.

_____

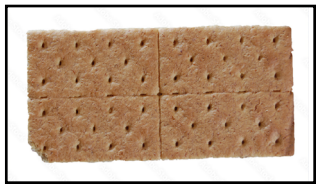
Finally, put the _____ on the _____.



Plate


Chocolate


Marshmallow


Graham Crackers

Mark the transition words you used:

___First ___Next ___Now ___After that ___Then ___Finally ___Last of all

2.B Robot Activity Guidelines (Alternative)

Instructions for robot
You will be interpreting the writer's directions word for word like a computer or robot would. Even though you already know how to make a s'more correctly, you can only follow the directions on paper as they were written. You job doesn't start until the writer finishes drafting their directions.

Once the writer is done:
Work through the list of directions given by the writer one at a time. Make sure to only follow exactly what is written. Read the first line of directions then carry out the task. *For example: if the first line is "break the chocolate bar into pieces", you should break the unwrapped bar into pieces instead of opening the wrapper first since the directions did not specify to unwrap the chocolate bar.* Continue to read then complete each line of directions.

Safety note:
If you are using a microwave for this activity, make sure the whole s'more is not in the microwave for more than 20 seconds or the marshmallow will explode.

2.C Informative Writing Organizer

Connection to Design Challenge Key Components	Description from Research	Example from Writing Samples	Connection to Design Challenge
Purpose: Why use informative writing?			
Types: What formats/categories of writing can be classified as informative?			
Structure: What are the elements necessary for an informative writing piece?			
Readers: What should informative writing do for the audience?			
Organization: How is informative writing organized?			

2.D Informative Writing Samples

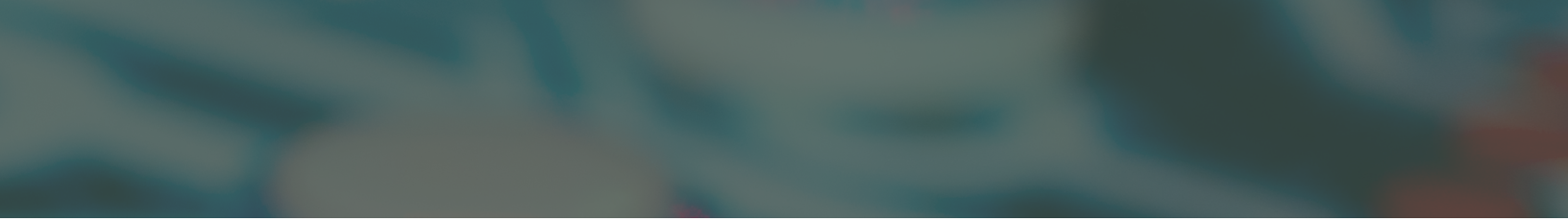
How-to example: https://www.meeplemountain.com/top-six/top-six-rules-for-writing-rulebooks/

News example: https://newsforkids.net/articles/2023/10/18/electronic-waste-day-highlights-invisible-e-waste/

Historic article: https://education.nationalgeographic.org/resource/worlds-first-computer-bug/

2.E Informative Writing Organizer Key

Connection to Design Challenge Key Components	Description from Research	Example from Writing Samples	Connection to Design Challenge
Purpose: Why use informative writing?			
Types: What formats/categories of writing can be classified as informative?			
Structure: What are the elements necessary for an informative writing piece?			
Readers: What should informative writing do for the audience?			
Organization: How is informative writing organized?			



LESSON THREE:

Lesson Objectives
Students will be able to:
- Annotate age-appropriate article using rubric.
- Use prior knowledge of informative writing to write and appropriate response to the prompt.
- Identify additional criteria and constraints from the client.

Time Required
One 45-minute lesson

Materials
Per classroom:
- EDP Poster

Per group (3 per group):
- Box of colorful pens

Per student:
- EDP slider w/ jumbo paperclip
- Laptop or equivalent device
- Engineering notebook

Standards Addressed
IAS English/Language Arts
- 7.W.4, 9-10.W.4

Key Terms
Screen time

Informative writing: Literary nonfiction, expository, argumentative, procedural

Logical flow: Chronological, order of importance/priority, step-by-step, description

Lesson Summary
Students will read and annotate an article about kids' screentime usage. Students will complete an informative writing assignment. There will be 2 options: students may write in paragraph form or practice procedural sequence writing. This writing activity will inform writing instruction and support throughout the unit. Students will read a client memo introducing the 5 divisions of the game board company.

Background
Teacher Background
Lesson Versions: Both the writing activity and the readings can be customized to fit specific students. For the articles the students will have to read, the three versions are on similar topics but are varying lengths and vocabulary levels.
- Option 1 is very short but it may be difficult to use this article for the writing activity since there isn't much that can be cut out for the summary.
- Option 2 is only slightly longer and these two options are fairly interchangeable.
- Option 3 has a lot more information and is from a research journal where K-12 students can submit their research papers. Option 3 fits best with the writing activity but can also be broken up within a group of students if it is too much information for students to get through in class.

For the writing activity, both versions require students to annotate their article and evaluate it using the 3.B Screen Usage Questions and Rubric. For both versions students identify key information needed to summarize the original article.
- Version 1 only really requires students to identify and pull out the structure of the original article and can be written using a list or bulleted statements and sequencing language (first, next, then, last).
- Version 2 includes identifying the structure and order of the information conveyed but students have to add any necessary details and construct the summary of the original article in paragraph form.

Before the Activity
- If you would like an example of an opinion piece to use as a comparison to informative writing, this is an option relevant to the screen time context: https://www.timeforkids.com/g34/share-screen-2/

- Print and make copies of the following duplication masters in the labeled amounts:
  - (Per student) 3.A Screen Usage Articles, 3.B Screen Usage Questions and Rubric, 3.C Client Memo 2

Classroom Instruction

Introduction

1. **Reintroduce the client's problem.**
2. **Revisit the EDP.**

Activity

3. **Distribute an article about the client's problem.** Pass out copies of one of the 3.A Screen Usage Articles out to the students.
   NOTE: Choose the grade level or reading level which best fits your classroom.
4. **Distribute annotation rubrics.** After passing the article out to students, pass out copies of the 3.B Screen Usage Questions and Rubric to each student. Distribute a set of colored pens to each group. **Say:** *You will use this rubric to annotate the article in front of you. Feel free to use the colored pens to indicate different criteria in the rubric. You can circle, underline, and make notes on the article itself.* Read over each criterion of the rubric making sure to answer student questions about the expectations for the activity.
5. **Students independently read and annotate the article.**
6. **Work in groups to fill in gaps.**
7. **Introduce the writing activity.** After all students have read and annotated the article, explain the writing activity to students. The writing activity includes one of two versions: Secondary Version will include writing a paragraph about the article, stating the main ideas of the article and the important information that students would need to know. Intermediate Version will include procedural sequence writing, such as listing order of ideas in a first, then, last type of listing.
8. **Complete the writing activity.** With both versions of the activity, students will need to rely on their annotated article to identify the main ideas and relay the information to an audience unfamiliar with the original article. Hand out the 3.D Article Outline organizer to help scaffold the activity. **Say:** *Use the main ideas and important information you found in your article to outline your summary. Think about the logical flow of the original article and if it would make more sense to readers to keep the*

Duplication Masters

- 3.A Screen Usage Articles
- 3.B Screen Usage Questions and Rubric
- 3.C Client Memo 2
- 3.D Article Outline

Assessment

Activity Embedded Assessment

Observe student completion of the 3.B Screen Usage Questions and Rubric to identify what they may be struggling with.

Post-Activity Assessment

Evaluate students' writing assignments (either paragraph summary or sequence activity).

information in the same order or change it up. Write your outline in your engineering notebook as a draft then when you are comfortable with the overall order of the information, add in the necessary details to create your summary.

9. **Self-evaluate article summary.** Once students have completed their summary, encourage them to self-evaluate their work using the same rubric they used to annotate the original article. **Say:** *You can use the 3.B Screen Questions and Rubric to check your summary. Revision is an important part of the writing process just like redesigning in engineering so make sure you take time to edit and revise your summary based on how well you addressed the criteria in the rubric.* Remind students that when working through the writing process or engineering design process, it is more important to fail and improve multiple times than it is to come up with the final product right away.
10. **Read 3.C Client Memo 2.** Hand out 3.C Client Memo 2 to each student and read the memo as a whole class.
11. **Identify additional criteria and constraints.**
12. **Determine student teams.** Group students in teams of three or four based on class size and student interest in a specific division of GEM described in 3.C Client Memo 2. These will be their design teams throughout the rest of the unit.

Closure

13. **Connect back to the engineering design challenge.**
14. **Revisit the EDP.**

3.A Screen Usage Articles

Option 1: https://www.timeforkids.com/g56/habits-healthy-brain-2/

3.A Screen Usage Articles

Option 2: https://kidshealth.org/en/teens/blue-light.html?ref=search

3.A Screen Usage Articles

Option 3: https://kids.frontiersin.org/articles/10.3389/frym.2013.00015

Name_____ Date_____ Period _____

3.B Screen Usage Questions and Rubric

1. **What genre is the article? Choose one:**

   - □ **News article**
   - □ **Instruction manual**
   - □ **Research paper**

2. **Who is the target audience that the author is addressing in the article? How do you know?**

3. **Complete the following rubric. For each row, determine whether the article meets the criteria for 0, 1, 2, or 3 points.**

Criteria	3 points: Meets all expectations.	2 points: Meets most expectations.	1 point: Partially meets expectations.	0 points: Does not meet expectations
The purpose of the article is easily identified.				
The author uses topic sentences in the article.				
The author used credible evidence to justify their claims.				

Name_____ Date_____ Period _____

3.B Screen Usage Questions and Rubric

The author wrote a structured (organized) and sequential (logical flow) article.				
The author identified the purpose (the "so what?") of the article for its audience.				

4. Describe ONE thing you would change to improve the article.

3.C Client Memo 2

Dear Engineers,

Thank you for accepting this task. Now, that you have learned about informative writing, you will use the skills you have learned to compose an instruction manual to accompany your game. When you are designing your game, we would like you to tailor it to one of our five divisions.

- Bilingual Boards is focused on creating games to help students learn languages. The same rules of board game design apply, but the games for this division often involve gameplay (not just instructions) that use more than language.

- Games 4 Girls is focused on creating games that are centered on girls' interests. Their mission statement is "Games for all." Game designers for this branch do research into how to appeal to the female demographic.

- Kollaborative Kwests is focused on "collaborative gameplay". The designers dive into how to bring players together to solve problems and overcome challenges as a team. Players win when their teams succeed.

- Athletic Adventures is focused on creating board games with a theme of sports. The designers consider how to translate the traditional rules of the particular sport into a game board setting.

- Vintage re-Vamped is focused on putting modern twists on classic board games. This division finds ways to reignite interest through redesign of traditional board games.

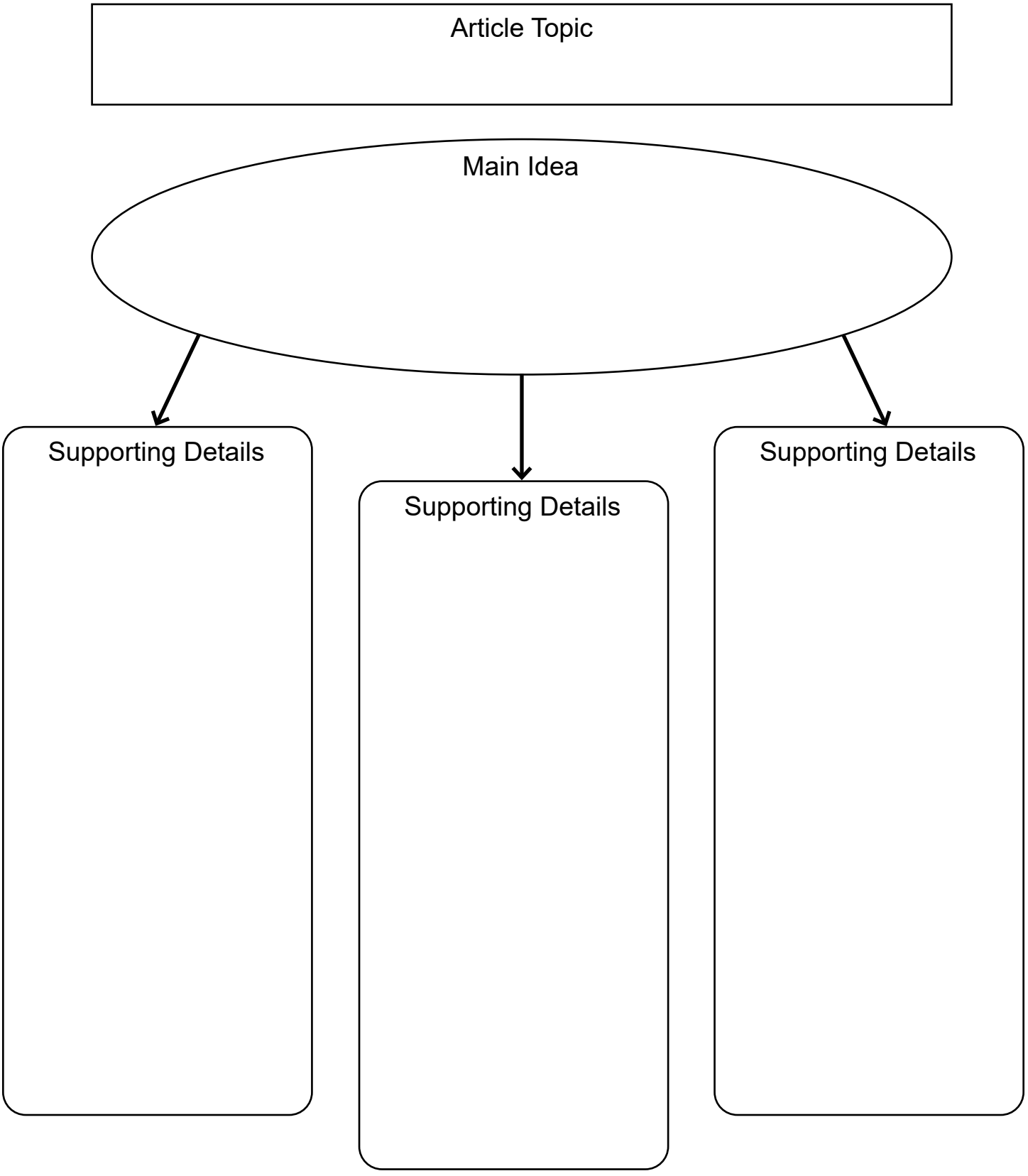
We are looking forward to hearing your ideas.
Sincerely,

Rubi Gonzalez

Rubí Gonzalez
Engineering Outreach Coordinator
Games, Electronics, and Motivation (GEM)

Name_____ Date_____ Period _____

3.D Article Outline



LESSON FOUR:

Lesson Objectives
Students will be able to:
- Identify information gaps and rewrite poorly written instructions.
- Annotate and identify criteria and constraints in a client letter.
- Complete brainstorming and notebook prompts for game concept.
- Communicate in groups and complete a game storyboard using evidence-based reasoning.

Time Required
Two/three 45-minute lessons

Materials
Per classroom:
- EDP Poster

Per group (3 per group):
- Box of colorful pens

Per student:
- EDP Slider w/ jumbo paperclip
- Laptop or equivalent device
- Engineering notebook

Standards Addressed
IAS English/Language Arts
- 5-6.W.2, 7.W.3.2, 9-10.W.2

IAS Integrated STEM
- 3-5-ETS1-1, 1-2, MS-ETS1-1, 1-2, 5-HS. IPS.1, IPS.2, IPS.3

Key Terms
evidence-based reasoning, justification, assumptions

Lesson Summary
Students will examine a set of instructions that are poorly written. They will make improvements to these instructions in the Make-it-Better Activity. Students will read another client memo, introducing constraints (3 gameboard templates), criteria, and the need to learn about micro:bits. Students will be given 3 basic game templates as a starting point to design their games. Students will individually brainstorm and complete the notebook prompt for what game concept they would like to do. They will meet in groups to decide and storyboard their game. Students will use evidence-based reasoning to justify their design decisions.

Background
Teacher Background
Evidence-Based Reasoning: Evidence-based reasoning (EBR) refers to the engineering practice of providing rational for design ideas and decisions. It is somewhat similar to scientific argumentation in the sense that it involves using evidence and explanations to support a statement, but it is ultimately different. In EBR, the statement being supported is an engineering design idea or decision, whereas in scientific argumentation it is a claim or conclusion about a natural phenomenon. EBR is used in the context or generating solutions for engineering problems; scientific argumentation is used to answer scientific questions about nature. Science and mathematical principles are important justification for scientific argumentation and EBR. However, EBR often also includes justifications related to context, criteria, and constraints of the engineering problem (e.g., cost, user needs, technical feasibility). In this lesson, students will use EBR to think deeply about their proposed decisions and to justify them with information about the engineering problem and their science and mathematics knowledge.

Before the Activity
- Project or display a large version of 4.F EBR Instructions so students can see what needs to be included.
- Print and make copies of the following duplication masters in the labeled amounts:
  - (Per student) 4.A Make-It-Better Activity, 4.B Client Memo 3, 4.C Gameboard Templates, 4.D Planning Prompts, 4.E Evidence-Based Reasoning Graphic
  - (Per team) 4.D Planning Prompts

Classroom Instruction

Introduction

1. **Revisit the engineering challenge from the client.**
2. **Identify where they are in the EDP. (Plan)**

Activity

3. **Introduce the Make-It-Better activity. Say:** *To better understand what qualities make-up a "good" set of instructions for a game, we are going to analyze instructions written to explain how to play tic-tac-toe. You'll have to read the provided rules and work in your teams to play a round of tic-tac-toe following those rules.*
4. **Hand out the 4.A Make-It-Better Activity. Say:** *Before you jump right in, make sure to follow the steps written out at the top of this activity. After you play the game only using the provided rules, you will need to fill out the organizer on the second page.*
5. **Have students read poorly written instructions and play the game. Say:** *As you play the game, think about what made the rules easy or hard to follow.* Once students have been given a chance to work through the first two steps of the activity, have them move on to analyzing the rules using the graphic organizer. **Say:** *Take some time individually to fill out the parts of the organizer that you can. You'll get a chance to discuss with your group next.* Give students some time to jot down some critiques of the rules and suggestions for improvement.
6. **Discuss an improve the instructions in groups. Say:** *Now that you've written down some ideas, come back together as a team to identify how the rules provided could be improved. You should add to your organizer based on the ideas shared in your group discussion.* If there is time you can given teams a chance to draft a new set of rules based on their suggestions.
7. **Reflect on the Make-It-Better activity.** Help students connect back to the engineering challenge. **Ask:** *Why is it important for us to understand the qualities that make up a "good" set of rules for a game?* Give students a chance to connect to the client's problem, their game designs, and the informative writing lessons. If students struggle here, remind them of the s'mores activity and the effect that unclear instructions can have on a task or game.
8. **Read client memo 3.** Hand out 4.B Client Memo 3 to each student and give them a few minutes to read the memo individually.

Assessment

Activity Embedded Assessment

Pay attention to how students collaborate to plan and justify their design decisions.

Post-Activity Assessment

Use the 4.G EBR Example as a guide to assess students' ability to justify their design decisions on the 4.E Evidence-Based Reasoning Graphic.

Duplication Masters

- 4.A Make-It-Better Activity
- 4.B Client Memo 3
- 4.C Gameboard Templates
- 4.D Planning Prompts
- 4.E Evidence-Based Reasoning Graphic

Educator Resources

- 4.F EBR Instructions
- 4.G EBR Example

9. **Identify where they are in the EDP. (Plan) Ask:** *Where are we going next in the EDP.* For the rest of this lesson students will be planning their boardgame designs.
10. **Annotate and review client memo 3.** Give students a chance to identify any new information given by the client that they will need to consider when planning their boardgame. They can discuss this in their teams so they are ready to share out what they identified.
11. **Develop a list of all criteria and constraints.** Have students look back across the original client letter and the three client memos. As a class, generate a list of criteria and constraints the client has given up to this point. It might be helpful to display this list for the rest of the lesson as students will be considering the scope of the problem as they plan their designs.
12. **Give time to review 3 gameboard templates. Hand out 4.C Gameboard Templates. Say:** *These are the three templates the client mentioned you will be able to choose from for your designs.* **Ask:** *Based on the information in the most recent client memo, why is the client restricting you to one of these three layouts?* The students should identify that because the company is trying to reuse traditional board games, they have to base their designs on common existing board game layouts.
13. **Allow students to individually brainstorm game concepts. Say:** *In your engineering notebook, list out any ideas you might have about your boardgame concepts. At this point just brainstorm individually and jot down any ideas related to your game. This could mean ideas you have about the template you want to choose, any pieces you may have, how you might incorporate a micro:bit, visual style, overall goal of the game, or individual rules you'd like to incorporate.* Give students a lot of time here to make sure they exhaust all possible ideas.
14. **Have students fill out the 4.D Planning Prompts table.** Hand out the 4.D Planning Prompts. **Say:** *Now that you have had time to brainstorm concepts related to your board game, narrow down or compile the results of your brainstorming into TWO main design ideas that you would like to share with your team. Fill out the planning table individually with those two ideas but don't answer the questions at the bottom yet. We will revisit those later.*
15. **Allow time to compile ideas as a group. Say:** *Use your best judgement to choose your favorite design idea to share with your group. Take turns sharing your top idea with your teammates. As you listen, jot down the positive qualities of each of the design ideas. If someone says something that sparks*

another idea or you have any feedback, keep notes in your engineering notebook to discuss with your team once everyone has the chance to share. Give students time to share their design ideas. **Say:** *As a group, you'll need to narrow down all of the ideas you just shared so you can have two solid design ideas you will be moving forward with as a team.* If students have trouble narrowing down their options or compromising, remind them to revisit to client's constraints and consider the end-users of their board game. Each team will need to settle on two ideas to continue planning their designs.

16. **Introduce evidence-based reasoning. Say:** *Engineers use evidence to make decisions, so you're going to fill out an evidence-based reasoning graphic through the rest of this lesson to justify your design decisions to the client.* Remember, this is one of the criteria given to us by the client. Display the 4.E EBR Graphic Description so students are able to reference what will go in each section.
17. **Review the engineering problem. Ask:** *What is the problem we are trying to solve for our client?* Allow students time to discuss as a class. **Ask:** *What is the difference between the end-users and the client. How do both the client and end-users impact how we make design decisions?*
18. **Review the criteria and constraints. Ask:** *What is the difference between criteria and constraints.* Refer to the list generated by the class earlier in the lesson.

    NOTE: If students are stuck here remind them that criteria are the requirements, or goals, of the desired solutions and constraints are the things that limit design possibilities.
19. **Introduce the concept of simplifying assumptions. Say:** *Engineers usually don't deal with every single aspect of a problem at once because that makes the problem too difficult to solve. Instead, they make a complex problem simpler, sometimes by ignoring some of the details of the problem and sometimes by pretending certain things are true about the problem when they actually aren't.* **Ask:** *What are some parts of our engineering challenge that we can make simpler?* This may be a difficult concept for students, so provide an example or two if students struggle.
    - **Simplifying assumptions (things to ignore):** appearance, durability, or in this case, cost, since the majority of the parts are assumed to be recycled or reused. It's rare that cost is something to ignore when working as an engineer.

- **Simplifying assumptions (assume certain things are true when they aren't):** materials used in the classroom are similar to those the client will use when manufacturing on a large scale.

20. **Explain what information goes in each of the remaining sections.** Have students guess what kind of information they think should go in the "Design Idea," "Data/Evidence," and "Justification" sections of the EBR graphic. This could include:
    - **Design Idea:** This can be a sketch with a brief description of the key components or rules of the board game.
    - **Data/Evidence:** Observations from informative writing activities or data from research that were used to inform the design idea.
    - **Justification:** Complete the sentences that state why you think your design will be successful. These sentences should refer to the problem, criteria, constraints, design idea, and data/evidence.
21. **Complete the EBR graphic as a team.** Hand out a copy of the 4.E Evidence-Based Reasoning Graphic to each team. Students should use their top two design ideas they decided on as a team to complete the template. Remind students to provide evidence for their design decisions. This will take some time and may require students within a team to split up and work on different sections of the graphic.
22. **Have teams fill out 4.D Planning Prompts questions as a team.** Once teams have finished filling out the EBR graphic, have them go back to the planning document they filled out individually and answer the questions at the bottom of the page. Answering the questions may require deliberation within a team but the information they filled out in the EBR graphic should help justify which design they choose.
23. **Teams pick a solution to try. Say:** *Now that each team has chosen a solution, we will move on to the next stage of the engineering design process.*

Closure

24. **Connect back to the engineering design challenge. Ask:** *What did we do today that helped us progress toward solving the client's problem?* Make sure students know that they learned more about how to improve badly written game instructions and planned out their team's design.
25. **Revisit the EDP. Ask:** *What stage or stages of the engineering design process were we in today? What stage of the EDP do you think we will be during our next class.* Most students will assume they will be in the try stage next however, the client told them they will need to learn how to code the micro:bits to incorporate them in the final designs. This is a chance to remind students that the EDP is iterative and sometimes they may have to jump around between stages to best solve the problem.

Name_____ Date_____ Period _____

4.A Make-It-Better Activity

Step one: Read the following tic-tac-toe rules with your team. Pay attention to aspects of informative writing which may have been used or ignored when these rules were written.

Step two: Follow the rules as written to try to play a round of tic-tac-toe. If you have an odd number in your group, you can rotate to make sure everyone gets a chance to try following the rules.

Step three: Fill out the Make-It-Better Organizer to improve the original rules.

Instructions for Tic-Tac-Toe

Players: 2

Materials needed: paper, writing utensil

Rules:

- Draw 9 boxes
- Alternate drawing X or O in each box depending on the player
- Select which player is going to be represented by X and which player will use O
- Whoever gets three in a row wins and draws a line
- It's possible to tie the game so no one wins

Name_____ Date_____ Period _____

4.A Make-It-Better Activity

Make-It-Better Organizer

	What is wrong with the provided rules?	What can you do to make the rules better?
Background information: setting up the game		
Logical flow: the order of and flow between rules		
Content: the information communicated in each rule		

4.B Client Memo 3

Dear Engineers,

The electronics division of GEM has many left-over micro:bits available for your use. You will need to learn how to code these and plan how to incorporate them into your game board. Because this is a prototype, we will need you to use as many recycled parts as possible for your game. We have three common templates that get recycled which you will have to choose between as the foundation for your game board. For your game to be considered for a final product, you must use evidence-based reasoning to provide justification for your design decisions.

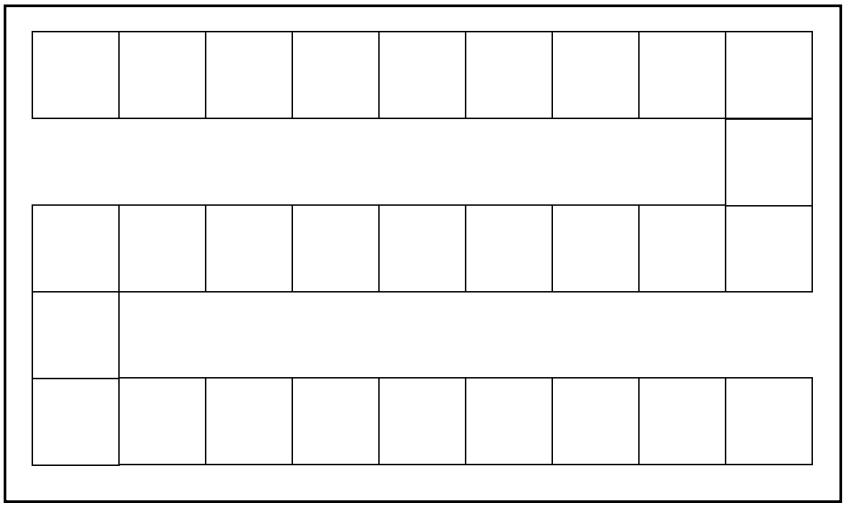
Sincerely,

Rubi Gonzalez

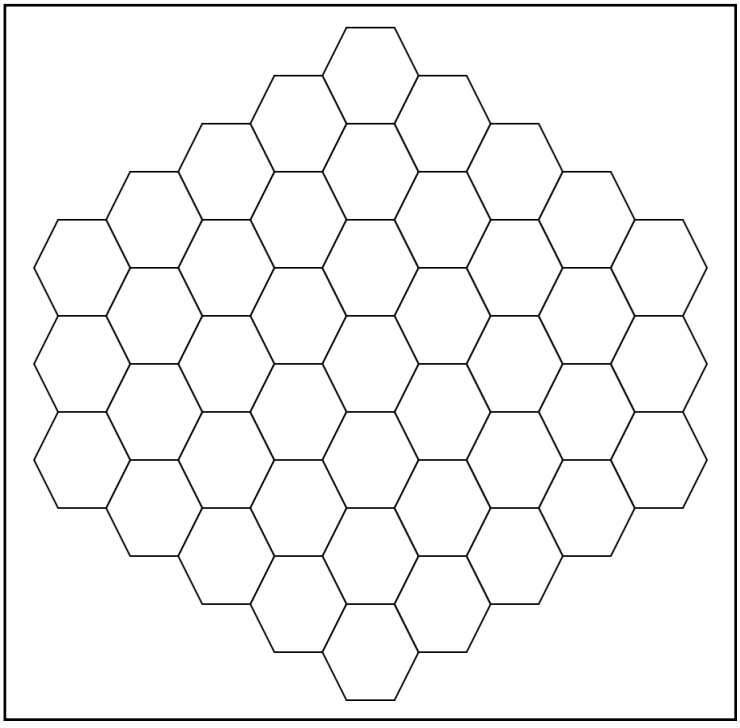
Rubí Gonzalez
Engineering Outreach Coordinator
Games, Electronics, and Motivation (GEM)

4.C Gameboard Templates

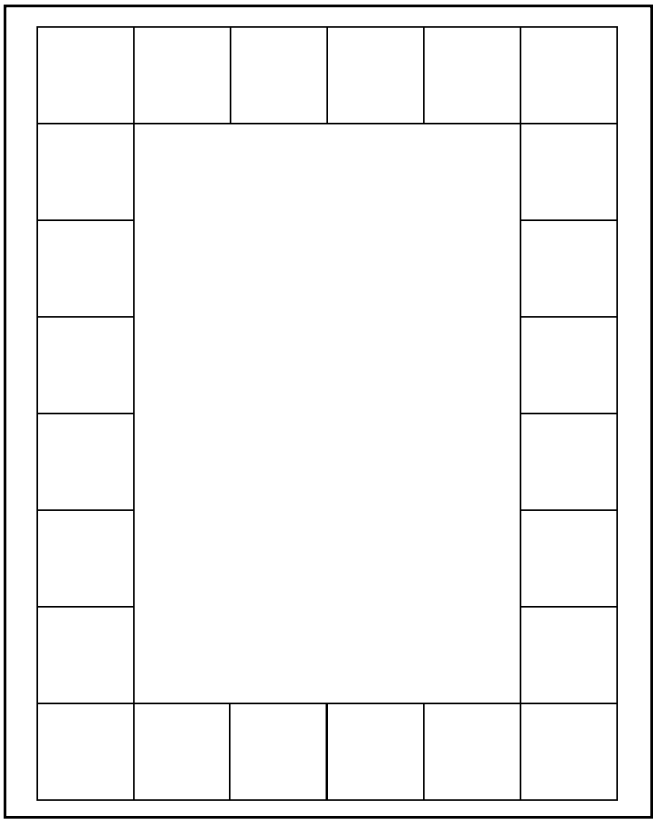
Template A



Template B



Template C



Name_____ Date_____ Period _____

4.D Planning Prompts

Directions: Fill out the table below individually after brainstorming. Do not answer the questions under the table until after selecting a solution with your team.

Solution Ideas	Pros of idea	Cons of idea	Address Criteria?	Meet Constraints?	Rank ideas
Idea 1:			yes / no	yes / no	
Idea 2:			yes / no	yes / no	

Answer these questions after selecting a solution with your team:

1. Which solution did your team choose and why?

2. What changes do you need to make before you try to implement your solution?

Name_____ Date_____ Period _____

4.E Evidence-Based Reasoning Graphic

Problem including Criteria & Constraints

- Explain the client's problem that needs a solution and why it is important to solve.
- List criteria and constraints you will use to decide if your solution is working.

Problem:

Criteria:

Constraints:

Simplifying Assumptions (if any)

- List things that might be important but you have decided not to worry about in order to focus the solution or simplify the analysis of the solution

Design Idea #1	Data/Evidence
• Plan including drawing, labels of materials used, and labels of what each part does.	• List science/mathematics learned and/or results of tests that support your design idea.

Justification - Why do you think this design idea will work?

- Explain how your data and evidence support your design idea in order to meet criteria/constraints.

Design Idea #2	Data/Evidence
• Plan including drawing, labels of materials used, and labels of what each part does.	• List science/mathematics learned and/or results of tests that support your design idea.

Justification - Why do you think this design idea will work?

- Explain how your data and evidence support your design idea in order to meet criteria/constraints.

4.F EBR Instructions

Problem including Constraints & Criteria	
Problem: the engineering problem the client asked you to solve Criteria: the requirements, or goals, of the designed solutions Constraints: things that limit design possibilities	
Simplifying Assumptions (if any)	
Ways to make a complex problem simpler - Things we ignore to focus the design or simplify analysis	
Idea #_____	**Data/Evidence**
• Description of the design • Drawings of the design, different views better • Dimensions (sizes) • Label materials in design (show where they are used) • Interesting features	Observations and data that show why you think your design will work Examples: • Data from science or mathematics lessons/labs/experiments • Total cost of design
Explanation, Justification, Reasoning	
Complete sentences that state why you think your design will be successful. These sentences should refer to the problem, criteria, constraints, idea, and data/evidence.	

4.G EBR Example

Problem including Criteria & Constraints
- Explain the client's problem that needs a solution and why it is important to solve.
- List criteria and constraints you will use to decide if your solution is working.

Problem: Kids are losing interest in board games because of increased screen time.
Criteria: traditional board game that utilizes microelectronics, board game tailored to a specific division within the client's company
Constraints: must reuse materials already in circulation, design has to incorporate a micro:bit, game board template can only be one of three pre-designed layouts

Simplifying Assumptions (if any)
- List things that might be important but you have decided not to worry about in order to focus the solution or simplify the analysis of the solution

- neglecting cost - this is because of a majority of materials in the design are being recycled by the client
- assuming materials the class has available are representative of the materials the client will use to manufacture the design on a larger scale

Design Idea #1 • Plan including drawing, labels of materials used, and labels of what each part does.	**Data/Evidence** • List science/mathematics learned and/or results of tests that support your design idea.
[Labeled sketch]	• Logical flow, sequencing, and organization of information improves reader understanding • Details are necessary for clear communication of instructions

Justification - Why do you think this design idea will work?
- Explain how your data and evidence support your design idea in order to meet criteria/constraints.

This design will work to help get kids interested in board games because the overall theme of the game is targeted to a specific division, the rules follow the informative writing principle of logical flow, and the rules are
concise enough for our end users to understand.

LESSON FIVE:

Lesson Objectives
Students will be able to:
- Explore sequencing through multi-modal representations.
- Code a micro:bit using block-based coding

Time Required
Two 45-minute lessons

Materials
Per classroom:
- EDP Poster

Per group (3 per group):
- Micro:bit, battery case, (2) AA batteries, USB to micro-USB cord

Per student:
- EDP slider w/ jumbo paperclip
- Laptop or equivalent device
- Engineering notebook

Standards Addressed
3-5.PA.2, 6-8.PA.1, HS.CC.3, 6.CC.2, 7.CC.2

Key Terms
micro:bit, code

Lesson Summary
Students will be introduced to coding and micro:bits through 3 different styles of activities: unplugged (which involves putting together code (Block or Python) puzzle pieces), embodied (which involves students having specific jobs/tasks and they are to put themselves in order to get the correct output), and plugged (which involves coding the micro:bit to fit within the constraints and criteria of the engineering design challenge).

Background
Teacher Background
The activities in this lesson are formatted with block-based coding. If you would like your students to complete these activities in Python instead of block-based coding, it is fairly straightforward to recreate the coding puzzles in MakeCode. Once you recreate the code using blocks, there is a toggle to click to view the code in Python instead.

Before the Activity
- Make sure students are able to access the links in duplication master 5.B.
- If you would like students to be able to easily manipulate the unplugged activity, make copies of duplication master 5.A then cut out the pieces. Alternatively, students can sketch or write out their solution to the unplugged puzzles.
- Before operating the micro:bits, at least one student in each team will need to create a microsoft MakeCode account so they can edit the links on duplication master 5.B.
- Make copies of the duplication masters in the following amounts:
  - (1 per student) 5.A Unplugged Activity, 5.B Coding Instructions, 5.C Client Memo 4

Classroom Instruction
Introduction
1. **Revisit the engineering challenge.**
2. **Identify where they are in the EDP (Learn).** Although students previously were in the plan stage, the client asked them to learn more about coding the micro:bits for incorporation into their board game designs. This is a good place to remind students that the engineering design process is iterative.

Activity

3. **Introduce a micro:bit.** Display the image from the following link: https://microbit.org/get-started/features/overview/#original-micro:bit. Give the class time to view the image and identify the components embedded in a micro:bit.
4. **Coding introduction video.** Show the class the video at the following link: https://www.youtube.com/watch?v=u2u7UJSRuko. After watching the video as a class, reflect on what students may have learned from the video. Encourage students to share additional prior knowledge they might have about coding or micro:bits.
5. **Have students solve the unplugged puzzles.** Hand out 5.A Unplugged Activity to each group. **Say:** *In your groups, read the instructions and work through each of the puzzles. You can cut up the code and move the blocks around to make it easier to visualize the final code.*
6. **Discuss challenges using the physical code. Ask:** *What did you find difficult about the puzzles you solved in this activity? What did you learn through the unplugged puzzle activity?*
7. **Connect to embodiment robot activity.** Have students reflect back on the robot activity from lesson 2 where they wrote tasks or "code" for another student to follow. **Ask:** *How was this activity similar to coding?*
8. **Connect the unplugged and embodied activities back to the design challenge.** Have students think about the important aspects of informative writing and how that compares to coding. They should be able to identify that sequencing and clear directions will be necessary for a sucessful solution to the client's problem.
9. **Introduce plugged coding activity.** Hand out duplication master 5.B to students. Hand out one micro:bit kit to each group consisting of a micro:bit, USB to micro-USB cord, battery case, and (2) AA batteries. **Say:** *At this point, you will need to think about how you want to incorporate the micro:bit into your game designs. Read through the options in step 1 of worksheet 5.B and decide if one of these can be integrated into your team's design. If you decide you want to get creative and venture outside of these options, the client will not have a starter code to provide and you will have to write your code from scratch.*
10. **Allow time for students to plan their code.** Give students time to work in their groups to integrate their overall plan for the board game with the micro:bit function they would like to use.
11. **Student coding of micro:bits for their game design.** Have student teams work through steps 2 and 3 of the 5.B Coding

Assessment

Activity Embedded Assessment

Listen to students as they work through the unplugged and embodied activities to evaluate their understanding of sequencing and logical flow.

Post-Activity Assessment

Identify whether or not teams were able to work together to code their micro:bit to perform the intended function.

Duplication Masters

- 5.A Unplugged Activity
- 5.B Coding Information
- 5.C Client Memo 4

Educator Resources

- 5.D Coding Solutions

Instructions. If groups get stuck, use the 5.D Coding Solutions to help them debug sections of their code.

Closure

12. **Read Client Memo 4.** Hand out 5.C Client Memo 4 to each student. Have students individually read the memo then discuss in small groups what they will be doing next.
13. **Identify where they are in the EDP. Ask:** *What stage of the design process were we in today?* (Learn) **Ask:** *What stage of the design process will we be in next?* (Try)
14. **Connect back to the engineering design challenge.** Discuss how the information students learned about coding will help them be more successful as the work to solve the client's problem.

Name_____ Date_____ Period _____

5.A Unplugged Activity

Background

When you coded your teammate to make a s'more or paper airplane, you used principles of informative writing like logical flow. Algorithms and sequencing are used in programming to make sure the directions to a computer are given in the right order to complete the task you want it to complete.

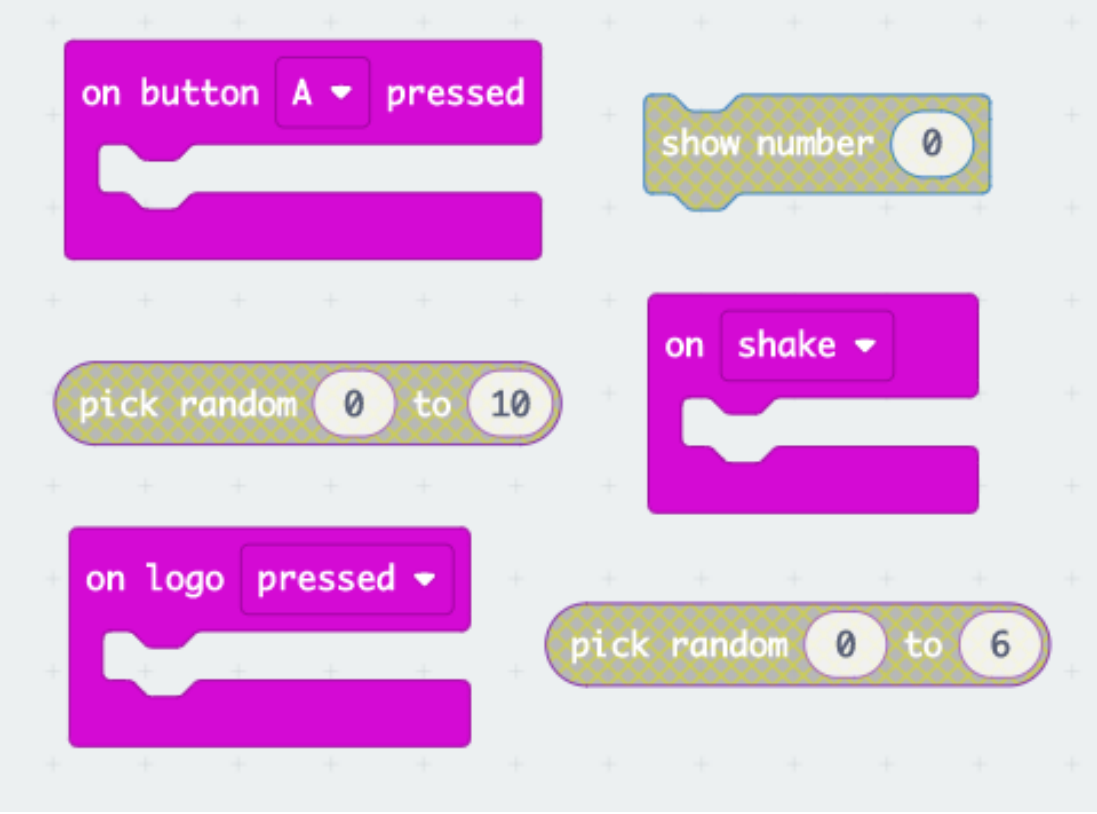
Algorithms are the processes or ordered sets of rules followed to accomplish a goal. By this definition, your game rules that you will develop are as much an algorithm for players to follow as they are a piece of informative writing.

Instructions

In this activity you'll rearrange or fill in the block-based code to accomplish the task described in each puzzle below. If there is time at the end you can check your solutions by creating the program in Microsoft MakeCode, downloading your solution on the micro:bit, and testing your solution to see if it performs the intended task. You can either cut out the puzzles to physically move the pieces or write/sketch your solutions in your engineering notebook.

Puzzle 1: Random number generator

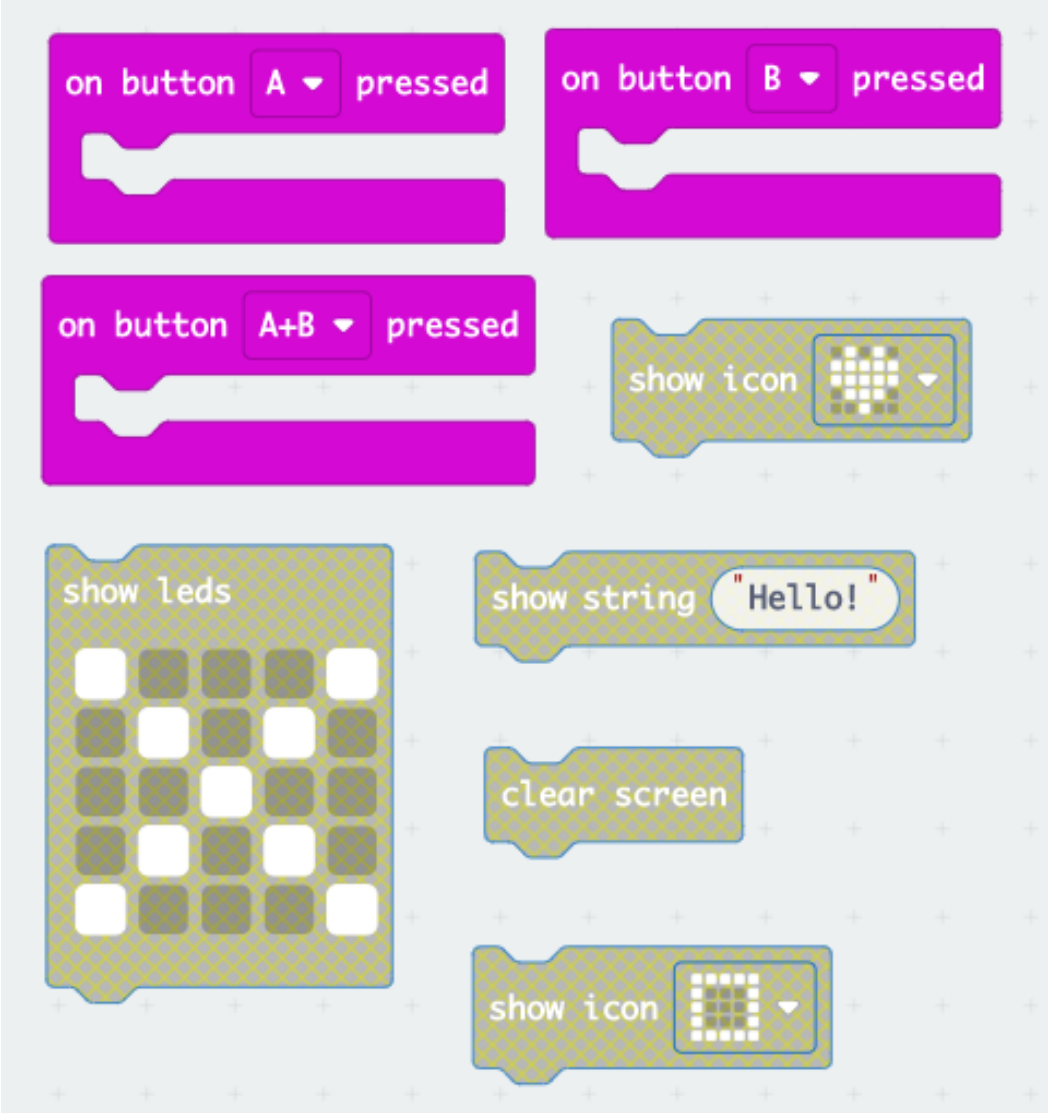
This puzzle has multiple options. You can put a lot of the pieces together but you do not need to use all of them. The only requirement is that the device has to display a random number triggered by some action (i.e. shaking the device).



Name_____ Date_____ Period _____

5.A Unplugged Activity

Puzzle 2: Show one image when you press button A and a different image when you press button B. Just like in Puzzle #1, you do not have to use all of the blocks.



5.B Coding Instructions

Step 1: Decide what you would like the micro:bit to do in your game. The following are examples of ways you can code the micro:bit which incorporate the built in sensors already a part of the device.

- Example 1: Using the micro:bit as a dice
- Example 2: Using the micro:bit to battle
- Example 3: Using the micro:bit to display a random symbol

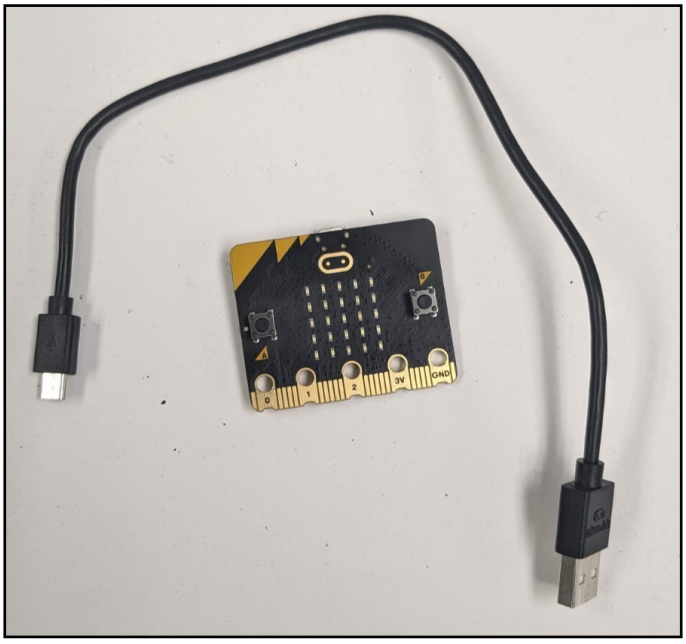
You do not have to choose one of these examples but if you decide to get creative, you won't have basic code provided to you as a starting place.

Step 2: Write the code you will use to program your micro:bit. You may use block-based coding or python. It's best to use browsers most compatible with the micro:bit like Microsoft Edge or Google Chrome. The starter code for each of the examples is provided in the following links. Make sure you click "Edit" in the top right corner so you can make changes based on your design. Once you click on the link you can switch between block-based coding and python to view the starter code in either version.

- Example 1: Randomly displays a number from 0 to 6 when you shake the micro:bit
  - V1 (easy) https://makecode.microbit.org/S07766-90378-42866-39345
  - V2 (hard) https://makecode.microbit.org/S78423-94577-08693-13232
- Example 2: After selecting A+B together, the battle can begin. Once the target is shown, the person who presses their button fastest wins and their letter is displayed on the screen.
  - V1 (medium) https://makecode.microbit.org/S86189-62448-16493-67500
- Example 3: Displays one of three random symbols every time button A is pressed.
  - V1 (medium) https://makecode.microbit.org/S03389-60709-33167-83652

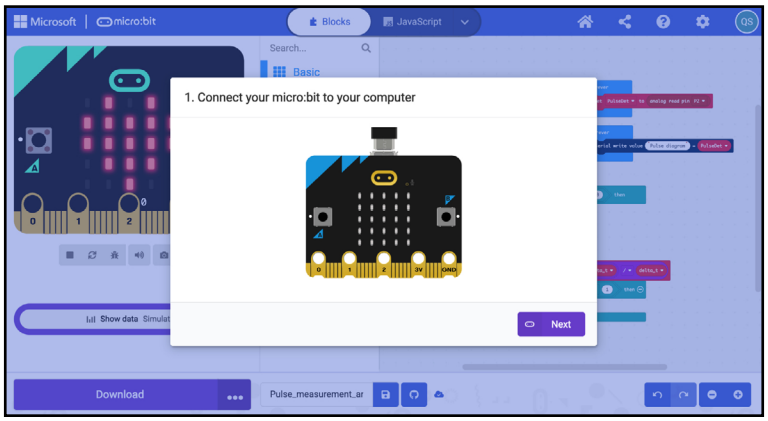
Step 3: Download your code to the micro:bit. Follow the process shown in the images to pair your micro:bit to your computer and download the code.

1. Connect your micro:bit to your laptop using the cord shown.

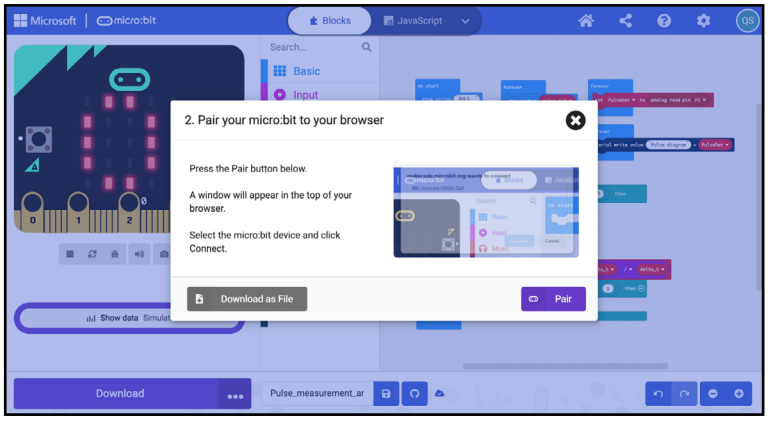


5.B Coding Instructions

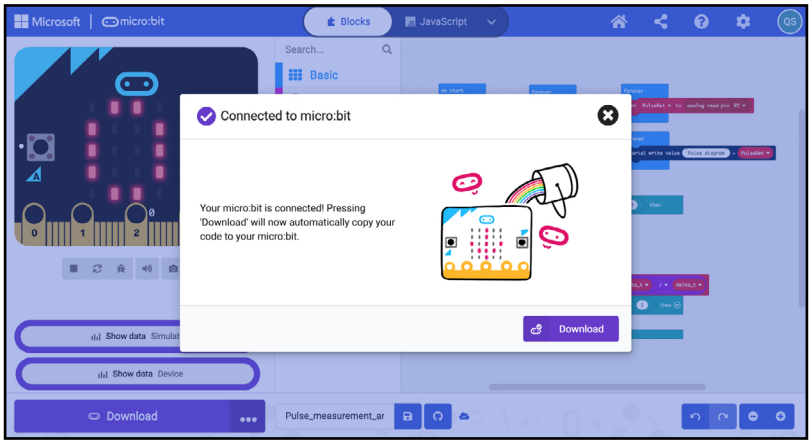
2. In your MakeCode window click the 3 dots next to download. Make sure you are signed into your MakeCode account and you are using Microsoft Edge or Google Chrome.



3. Click on pair to connect your micro:bit and laptop.



4. Now as you continue to make any changes to your code. Just click download while the micro:bit is connected.



5. If you want the micro:bit to function offline, disconnect from the laptop and plug the battery pack into the micro:bit.

5.C Client Memo 4

Dear Engineers,

Now that you understand how to code and integrate the micro:bit, your team should build your prototype then complete alpha and beta testing. For alpha testing, your group will playtest your game and check the instructions to make sure that gameplayers understand the concept and mechanics of the game. After making tweaks, your group will work with other engineering teams to beta test. They will play and evaluate your game using a rubric to give you feedback. You will do the same for them.

This process should help you get ready to present your final game design and justify your decisions.

Sincerely,

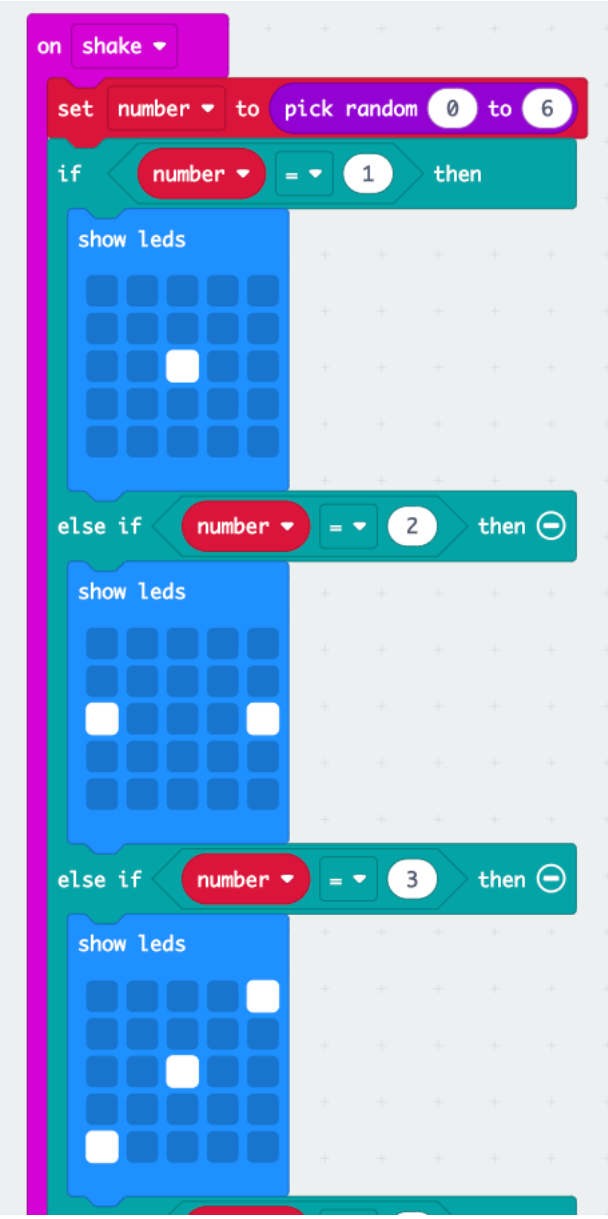
Rubi Gonzalez

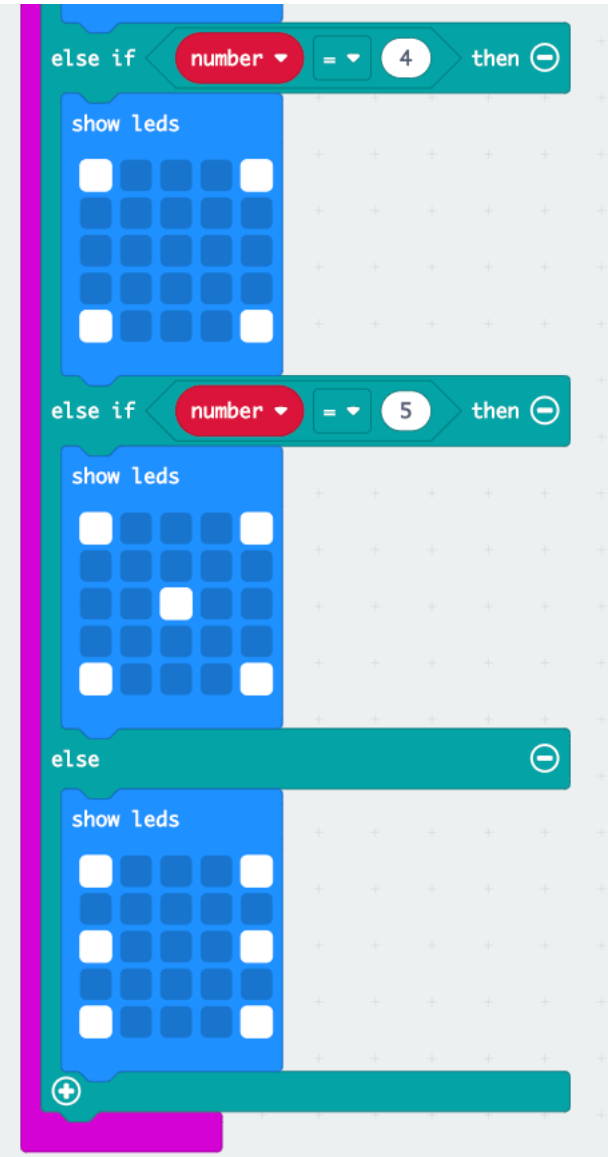
Rubí Gonzalez
Engineering Outreach Coordinator
Games, Electronics, and Motivation (GEM)

5.D Coding Solutions

Dice Code V1

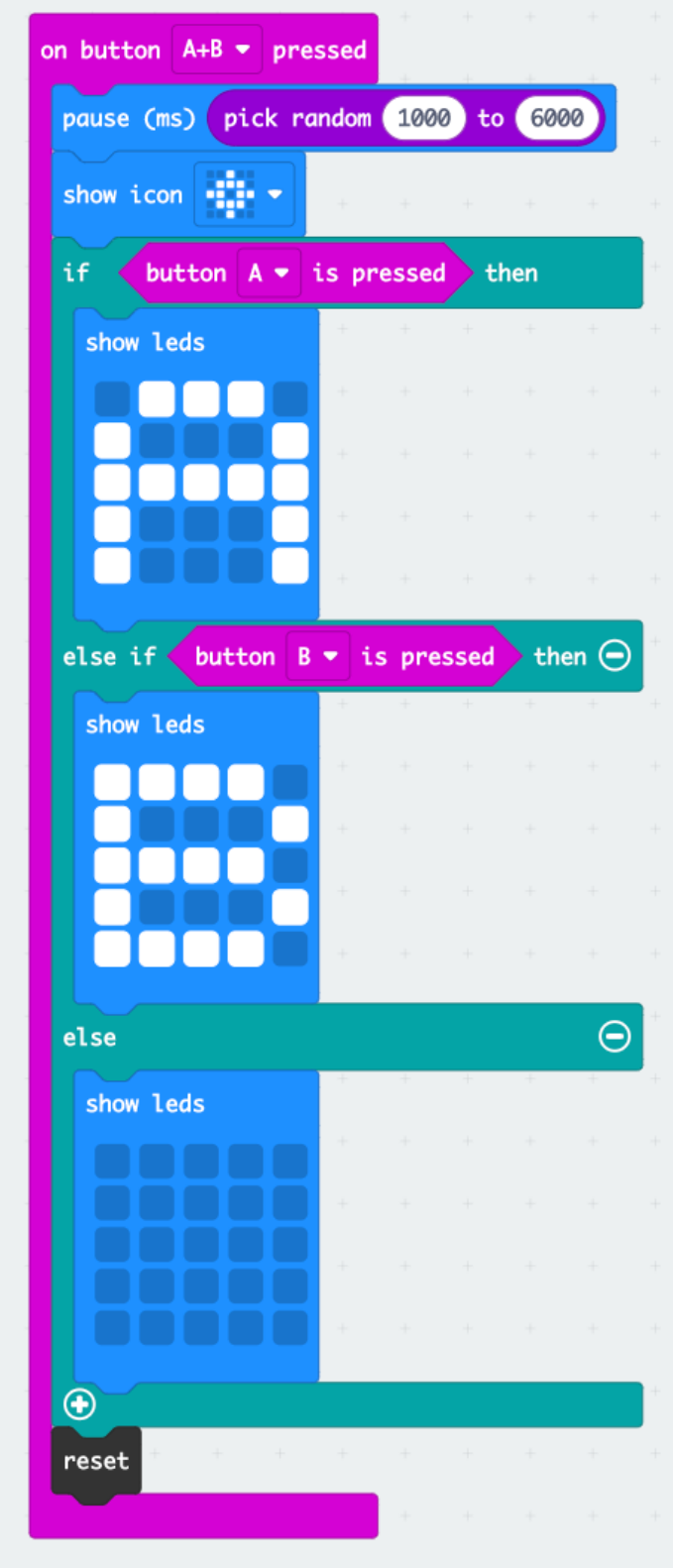
Dice Code V2





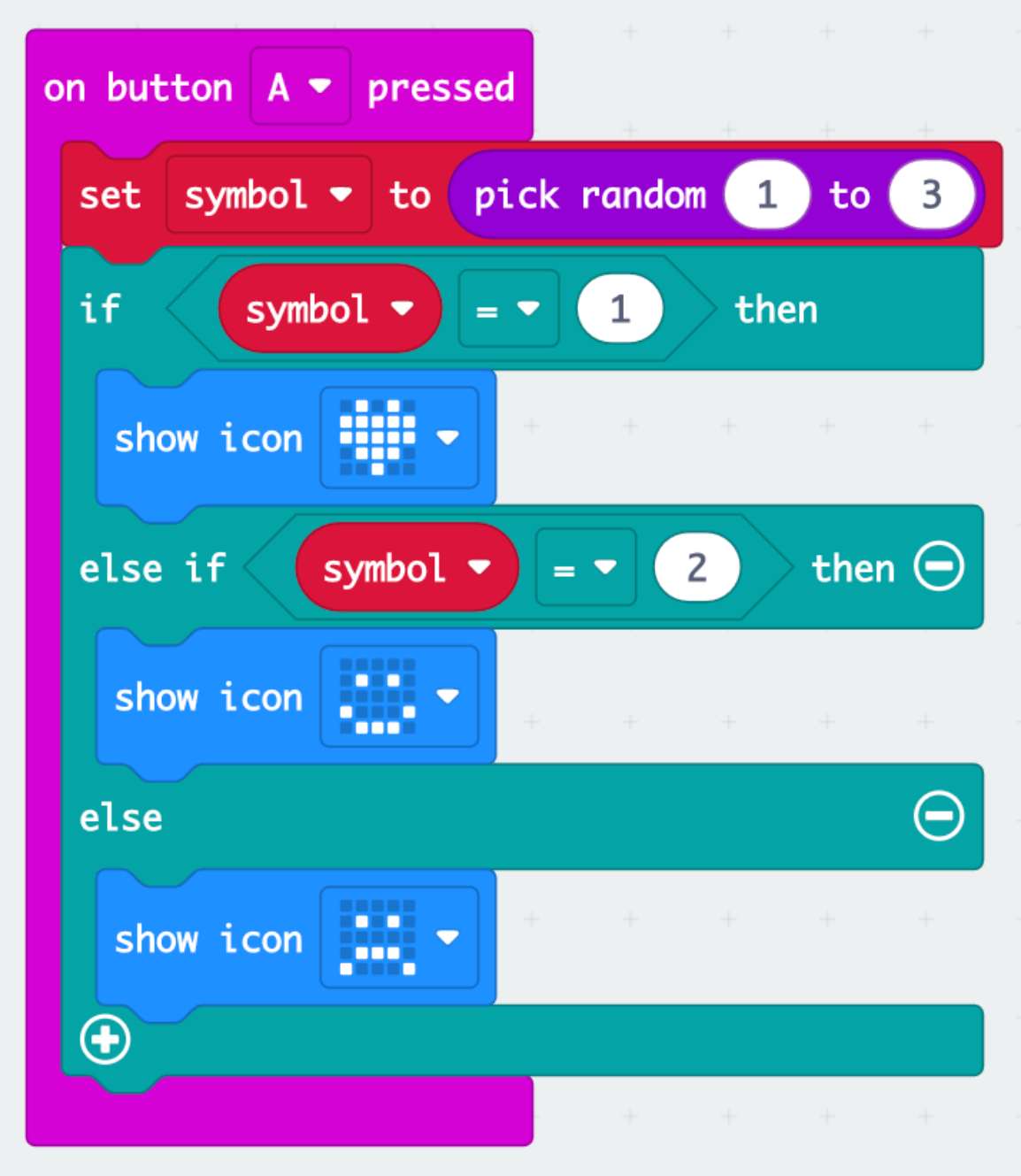
5.D Coding Solutions

Battle Code V1



5.D Coding Solutions

Symbol Code V1



LESSON SIX:

Lesson Objectives
Students will be able to:
- Evaluate their role in an academically-minded teams.
- Craft clear instructions following the writing process.
- Collaboratively construct a game prototype.
- Evaluate their game instructions through testing.

Time Required
Two 45-minute lessons

Lesson Materials
Per classroom:
- EDP Poster
- Construction paper
- Pipe cleaners
- String
- Popsicle sticks
- (2) Glue Bottles
- (2) Glue Sticks
- (2) tape
- (optional) materials from home

Per group (3 per group):
- Foldable gameboard base
- Box of colorful pens
- Micro:bit kit

Per Student:
- EDP slider w/ jumbo paperclip
- Laptop or equivalent device
- Engineering notebook

Key Terms
constraint, criteria, design, draft, evidence-based reasoning, alphatest

Lesson Summary
Students will compose their instruction manual draft and build their game prototype. Students will test their own games before design review.

Background
Teacher Background
Try: In this phase of the engineering design process students will need to apply their plans to build out the three main components of their groups design: the coded micro:bit, the game rules, and the game board. It is very important that students follow their plans instead of trying to make adjustments as they go since they have justified all of the design decisions they have made so far using prior knowledge and evidence. Some students often put off trying their designs because they feel pressure to get everything “right” the first time. This is a good opportunity to remind students that the design process is iterative for a reason and the best engineers try things out, fail, and improve them to make their designs better. If they are worried about making mistakes have teams use only the paper versions of the board game templates to develop their first prototype of the physical board instead of the foldable cardboard base. That way they can attach their prototype to the base when redesigning or they can transfer elements they like to a new paper template after testing.

Test: Students will have two chances to test and redesign their board game components. In this lesson they will self-evaluate their group’s solution, reflect on what they have learned, and redesign their instructions to prepare for a more formal testing process.
In the next lesson, groups will playtest each other’s games and evaluate them to provide constructive feedback. Each group will then reflect on the testing process and the feedback they have received to redesign all of their board game components and generate their final designs.

Before the Activity
- Assemble board game templates for each group
  - Each team should have chosen a template. The templates each take up four pages of duplication master 6.A. The four templates are designed to fit a traditional 18”x18” foldable game board base.
  - If you are not assembling the templates ahead of time, make sure each group has the four page template corresponding

to their team's design, the foldable base, scissors, and glue or tape.

- Prepare a variety of building materials for the class
  NOTE: To address the criteria of using recycled materials, students can be encouraged to bring in items they have at home to incorporate into their designs. Additionally, all of the building materials should be common items used in classrooms to simulate using resources which are typically readily available to students.
- Print duplication masters in the following amounts:
  - (1 per group) 6.A Gameboard Templates NOTE: Only 4 of the 12 pages should be printed for each group according to the version that matches their design.
  - (1 per student) 6.B Testing Reflection 1

Classroom Instruction

Introduction

1. **Revisit the engineering challenge. Ask:** *What is the client's problem? What are the criteria and constraints we have been given? What are some of the things we have learned that we are using to best solve the client's problem?*
2. **Identify where they are in the EDP. Ask:** *What stage of the EDP were we in during the last lesson?* **S**tudents should identify they revisited the learn stage to figure out how to write code for a micro:bit. Remind students that as part of lesson 5 they worked through the plan stage and try stage of the EDP as they coded the electronic components of their game design. **Ask:** *What stage of the EDP will we work through today?* (Try) **Say:** *Today you will try your game instructions and your physical board game prototype.*

Activity

3. **Review their storyboard.** Give teams some time to revise or complete their plans from lesson 4. **Say:** *Use the information you learned about micro:bits and coding in the last lesson to revise the evidence-based reasoning graphic in your engineering notebook. Work in your teams to make sure you know how you want to incorporate the micro:bit in the first prototype for your game.* If students need to debug or recode their micro:bit to prepare for testing, they should do that now. **NOTE:** If the micro:bits are shared between class sections, groups will need to redownload their code onto the micro:bit at the beginning of each lesson from now on.

Standards Addressed
7.W.3.2, 9-10.W.2, 7.W.4, 9-10.W.4, 7.IPS.1, HS.IPS.1 5-6.IPS.2, 7.IPS.2, HS.IPS.2, 7.IPS.3, HS.IPS.3

Assessment

Pre-Activity Assessment
As groups work on adjusting their overall plan, listen to how they incorporate what they've learned about microelectronics and coding.

Activity Embedded Assessment
Pay attention to how students work in their teams to build out their instructions and board game designs especially noting the extent to which they rely on their plan.

Post-Activity Assessment
Review 6.B Testing Reflection 1 from students' engineering notebooks to see how they self-evaluated their original instructions.

Duplication Masters
6.A Gameboard Templates
6.B Testing Reflection 1

4. **Draft their game instructions. Say:** *Now that you have decided on a plan for your team's game, you need to spend time using what you have learned about informative writing to draft instructions for your game.* This step may take the teams a while to work through; make sure they know if does not have to be perfect. Engineers come up with the best plan they can, but they test and redesign their solutions iteratively and the first solution is rarely the one that makes the final cut. **Say:** *Use your engineering notebook to come up with your first draft of the rules. It will need to be legible so other groups can follow it during the testing process, but it doesn't need to be pretty. After testing and redesigning your board game and instructions, you will have the option to use a template to create the publishable, final version of your game instructions.*
5. **Build their game prototype.** Provide student teams with their chosen template for their game design. Make sure each group has a complete set of materials to build with shown in the materials list in the margins of this lesson. Students should be following their plans that they updated from lesson 4. **Say:** *You can use all of the materials you have access to while building the physical board game. However, you will be testing and redesigning your prototype so you may want to make your initial design on the paper template instead of attaching it to the foldable cardboard base. That way you can attach or recreate your final design on the cardboard base after testing. At this stage it is most important to build all of the necessary components of your game to prepare for testing so if you aren't able to decorate how you'd like, you will get the change to incorporate this in your final design.*
6. **Playtest their game within their group.** *Have each group self-evaluate constraints, criteria, and playability.* **Say:** *Now that you have tried all of your components, we will be moving on to the testing phase of the EDP. In your teams, take some time to play the game using the instructions, board, and electronic components as they are currently built.* Remind students to follow their instructions as written like they did in lesson 2 during the robot activity instead of playing the game how they intended the instructions to be interpreted. **Say:** *As you play, jot down notes about what is and is not working. Make sure to think about the how your design addresses the criteria and constraints given by the client.*
7. **Reflect on the first round of testing.** Hand out 6.B Testing Reflection 1 to each student. **Say:** *Use these prompts to reflect on what you have learned about your instructions, game board,*

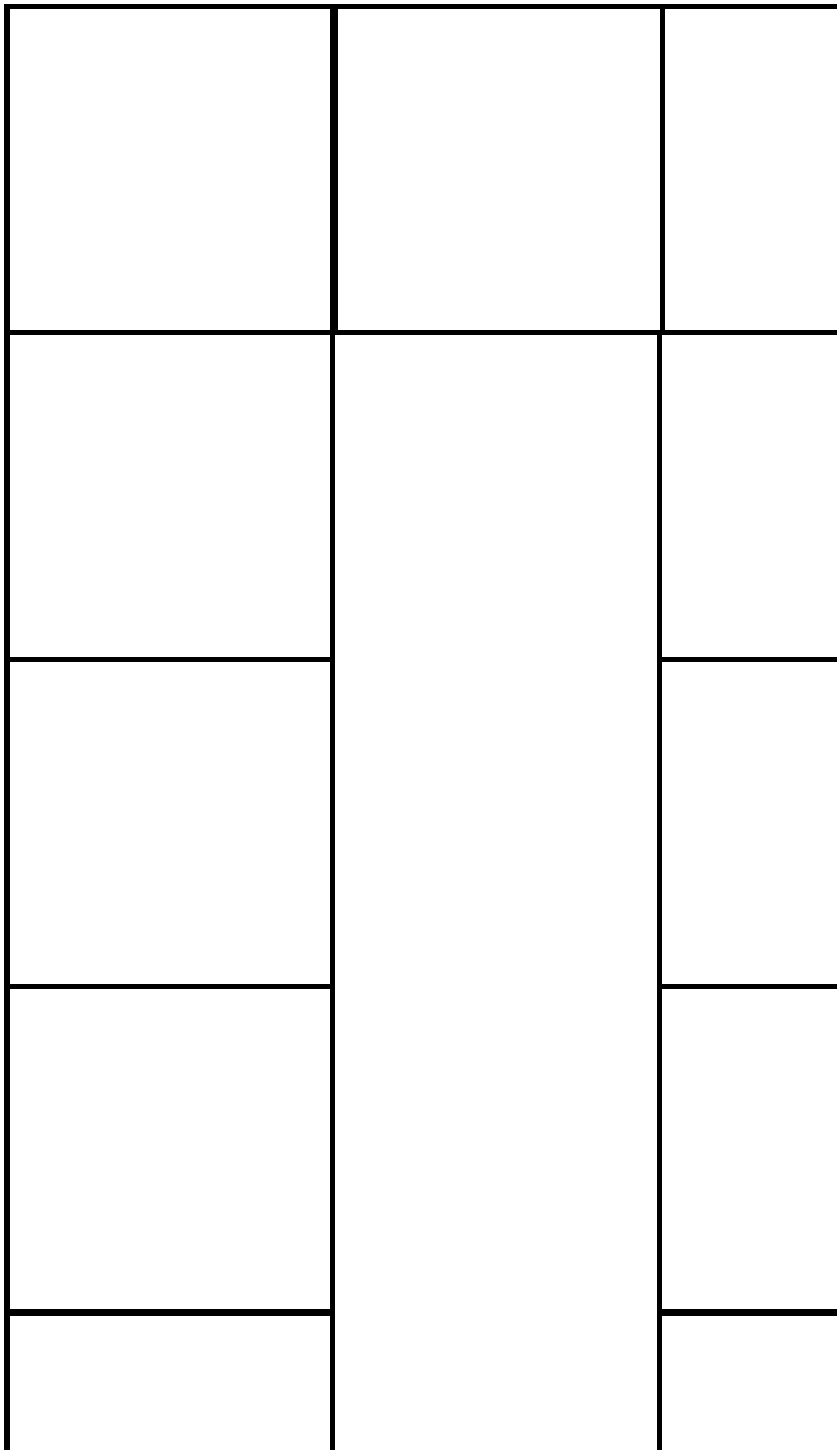
and electronics components. Give students time to reflect and identify what they need to change.

8. **Refine game instructions.** This phase of the redesign process is focused only on improving the design of their game rules. If there are other components which require necessary improvement to make sure the game is functional for other teams, groups may make those improvements as well. The goal here is to really focus on the informative writing elements which need to be redesigned so the teams can figure out how to play each other's games without input from the game designers. **Say:** *Use what you learned from the first round of testing and reflection to redesign your game rules. Make sure your rules can be understood by anyone in the class who has never played your game before.*

Closure

9. **Connect back to the engineering design challenge. Ask:** *What is our client's problem? How are we incorporating the criteria and constraints in your solutions?* Allow students the change to discuss their answers as a class. **Say:** *The type of testing you all experienced today is known as alpha testing in many industries. Alpha testing is an internal evaluation typically done by those who helped create the game or software. Beta testing is the next phase which is done by a small sample of end users. You will be simulating beta testing in the next class by playing and evaluating another group's design.*
10. **Revisit the EDP. Ask:** *What phase(s) of the EDP did we spend time on today?* Depending on how long this lesson took students worked through try and began to test. **Ask:** *What phase will be working on next time? (Test)*

6.A Gameboard Template (Option 1)



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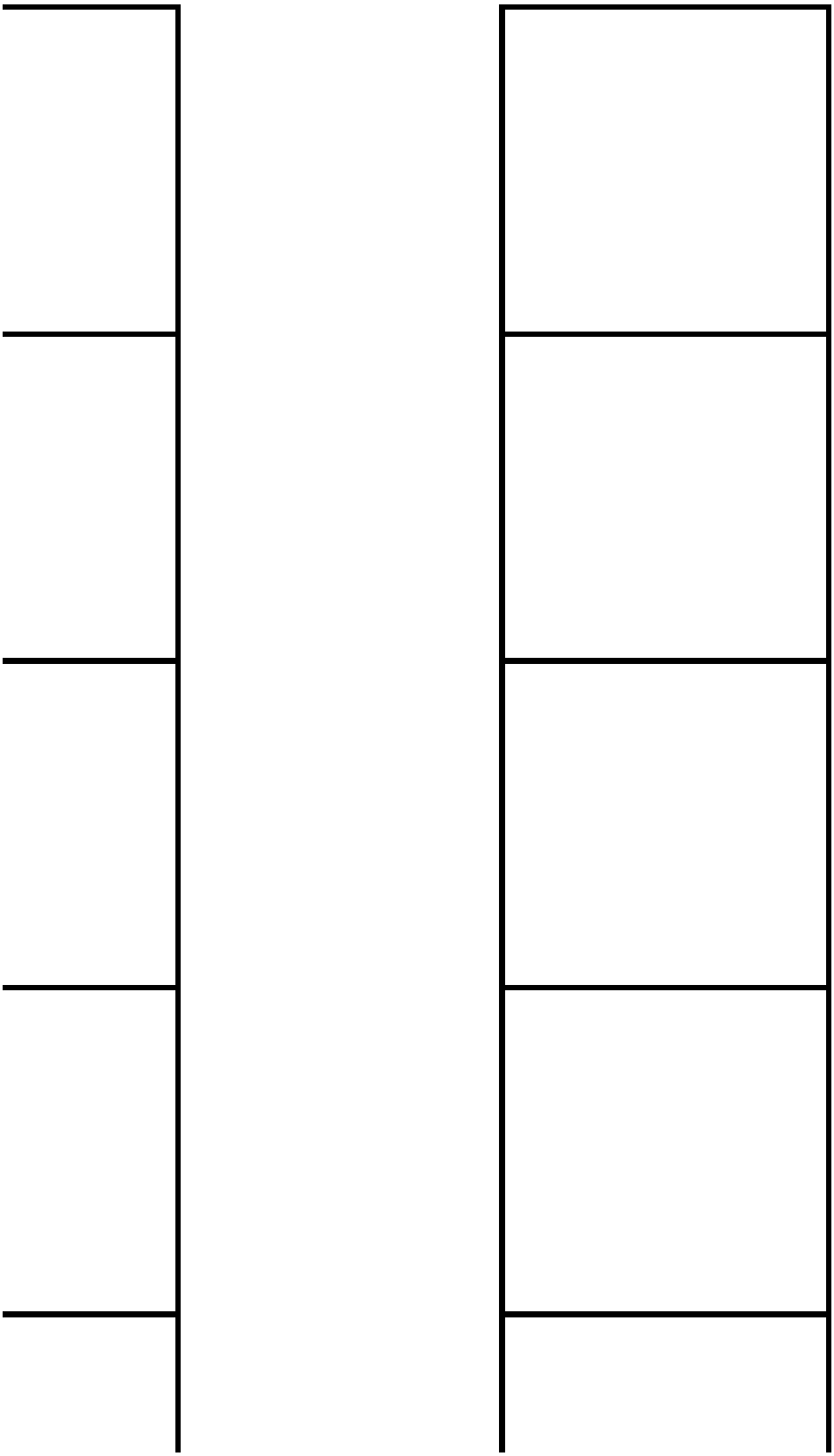

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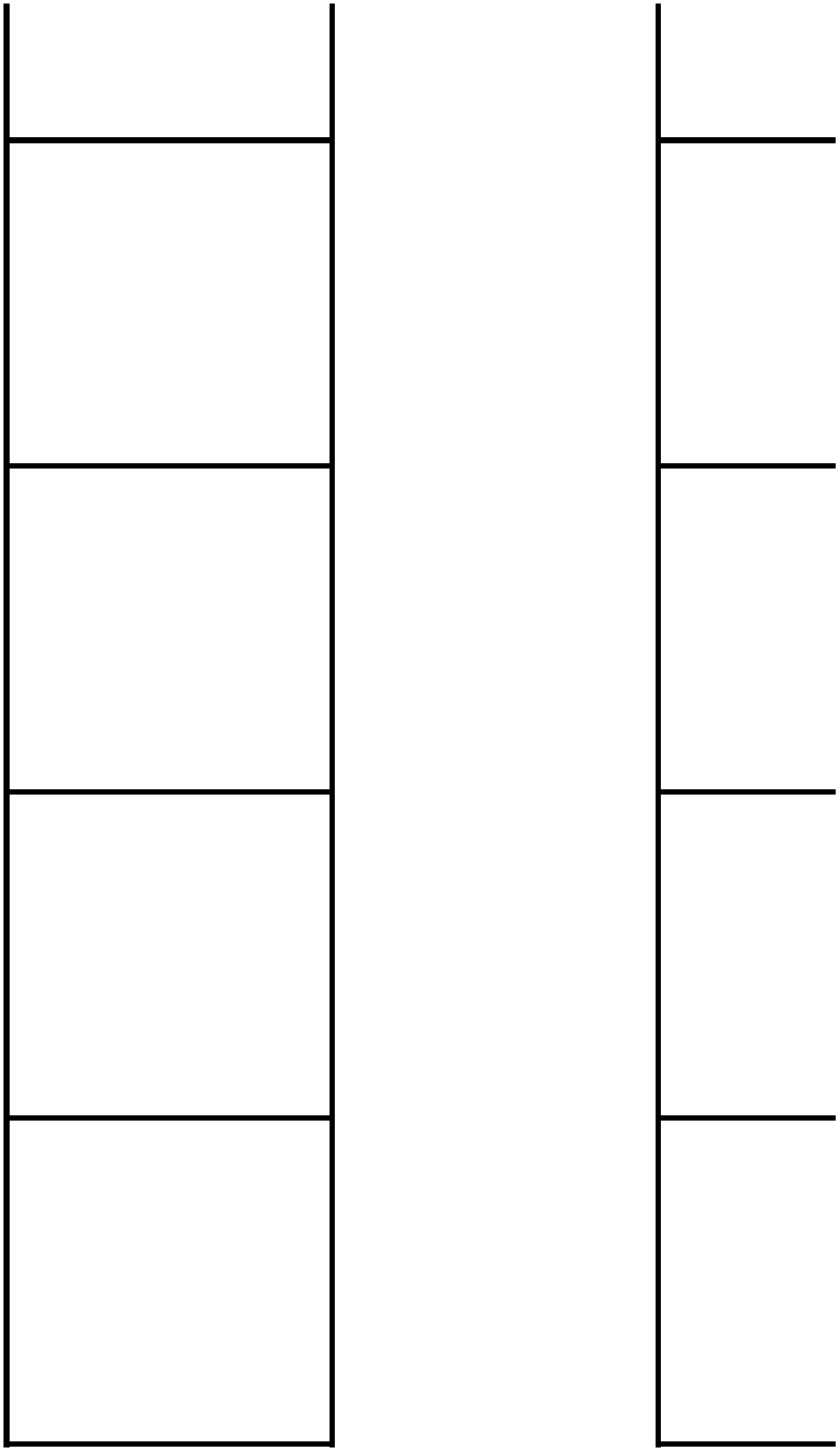

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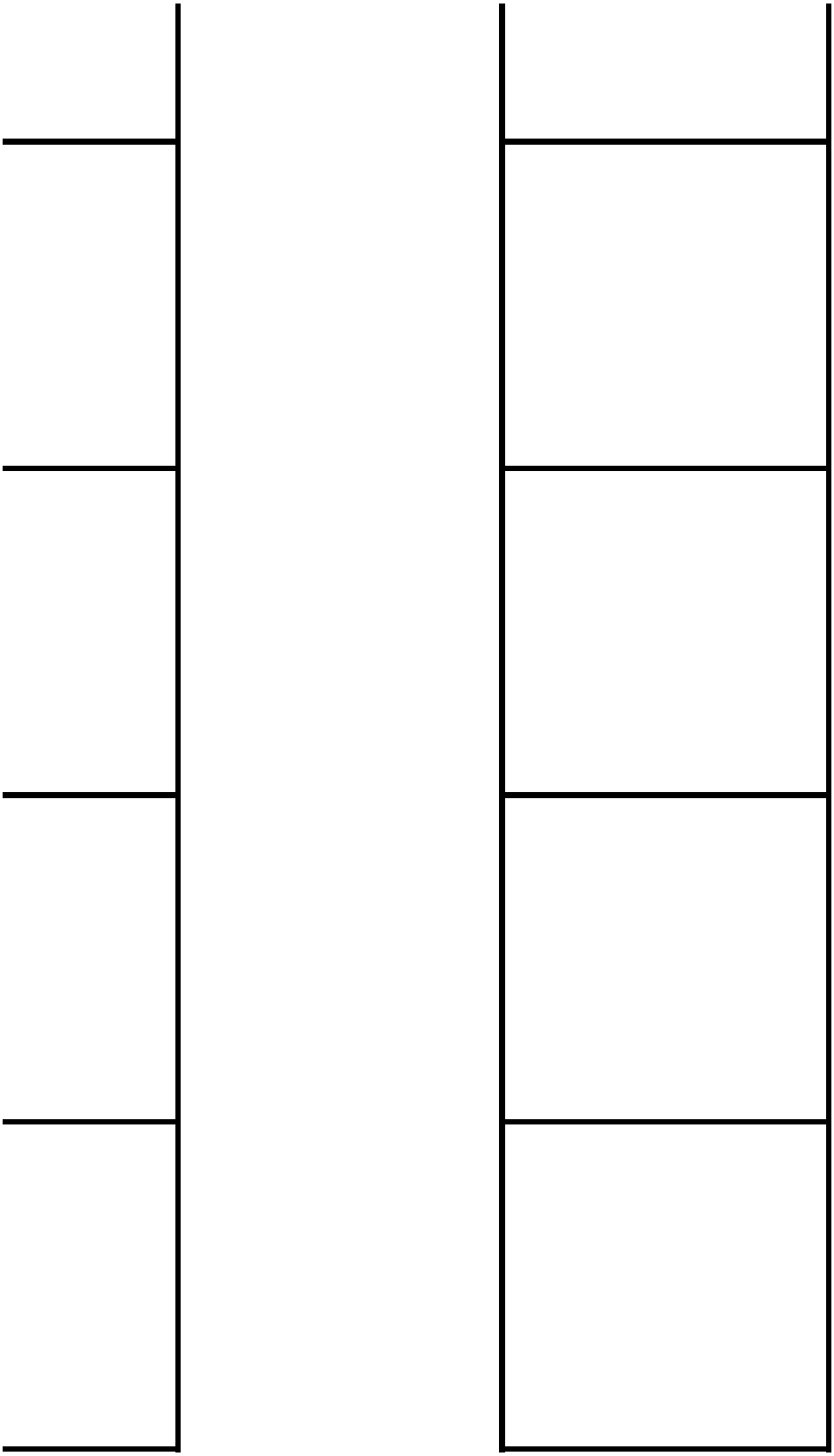

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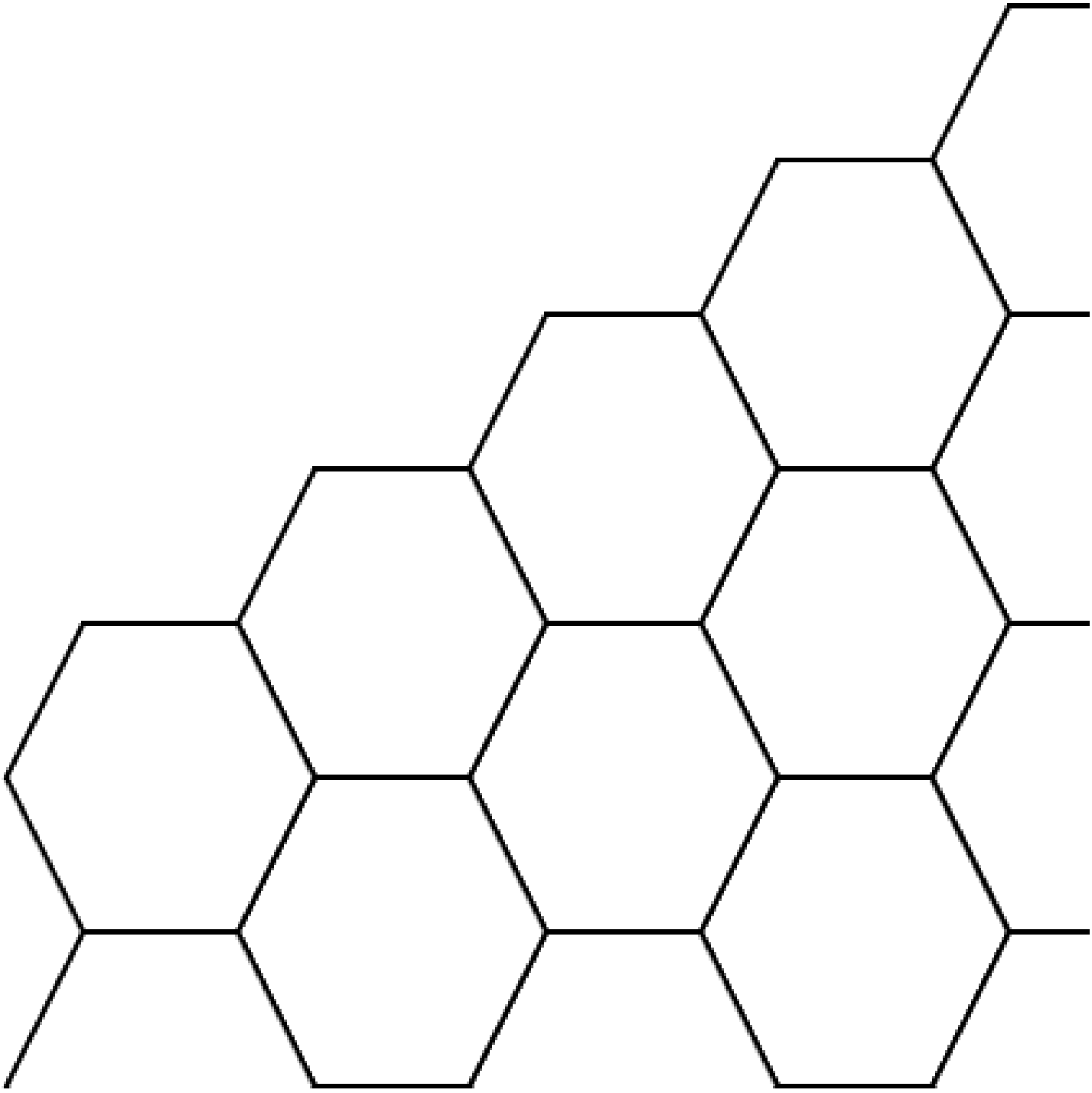

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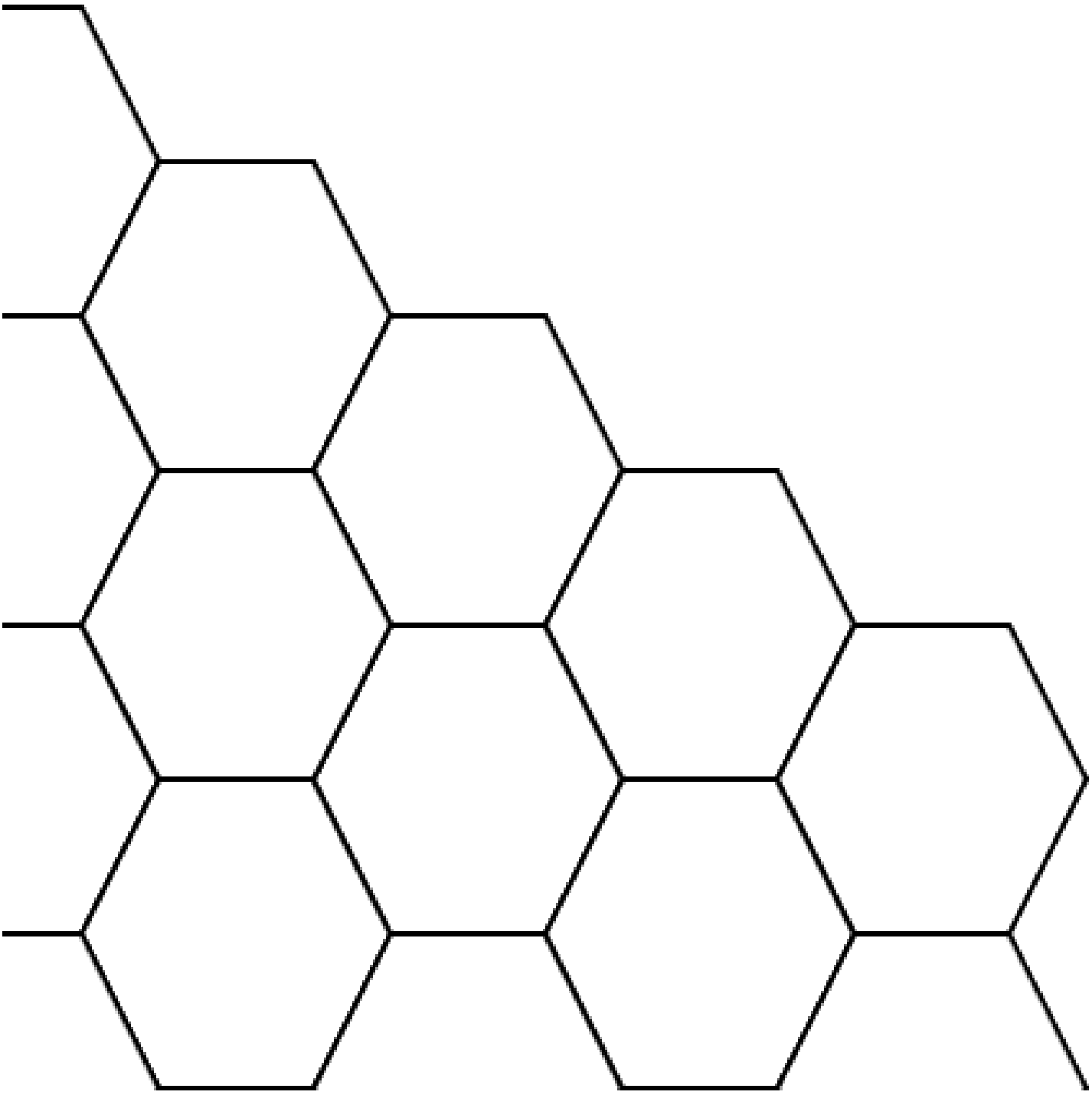

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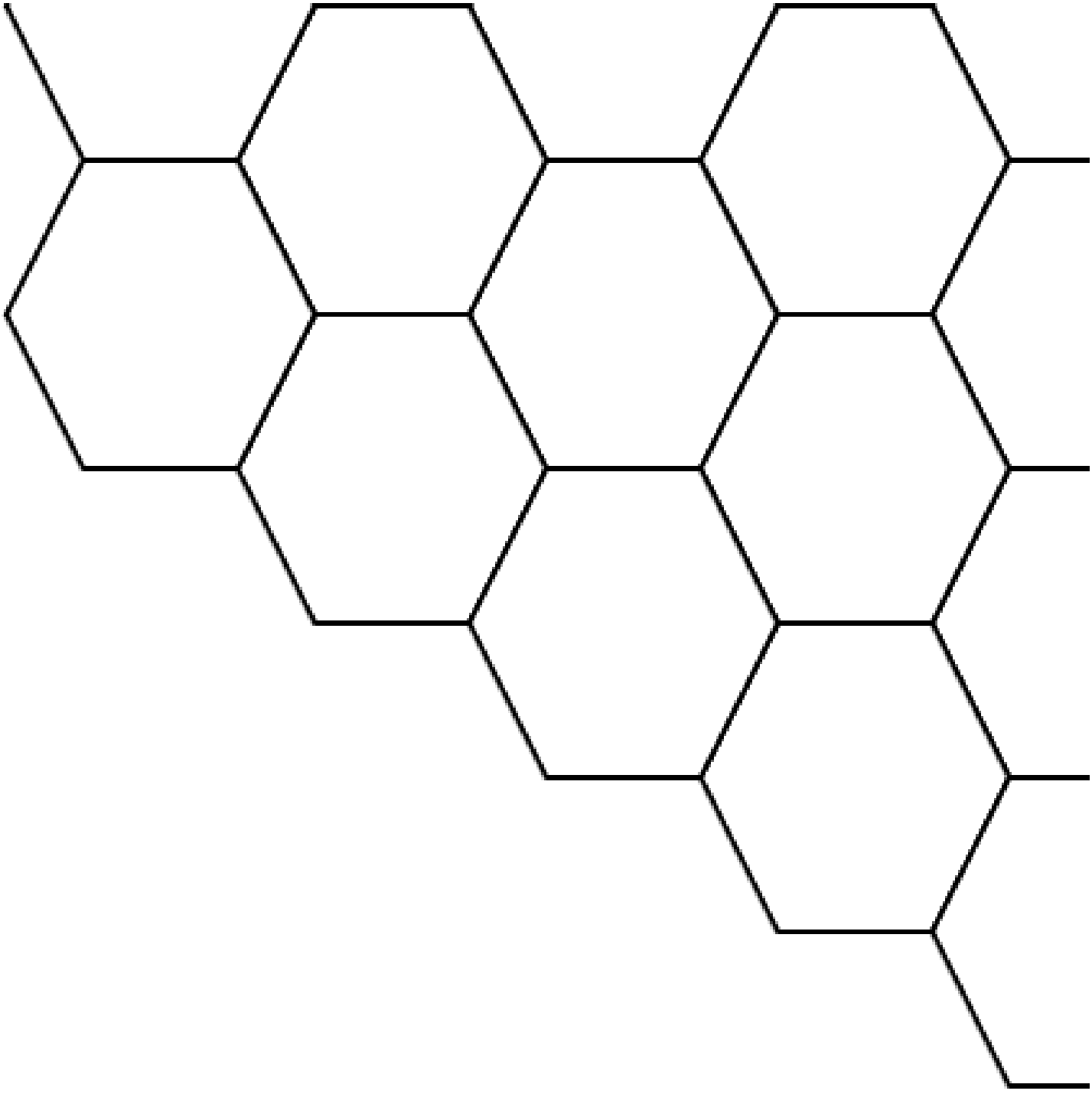

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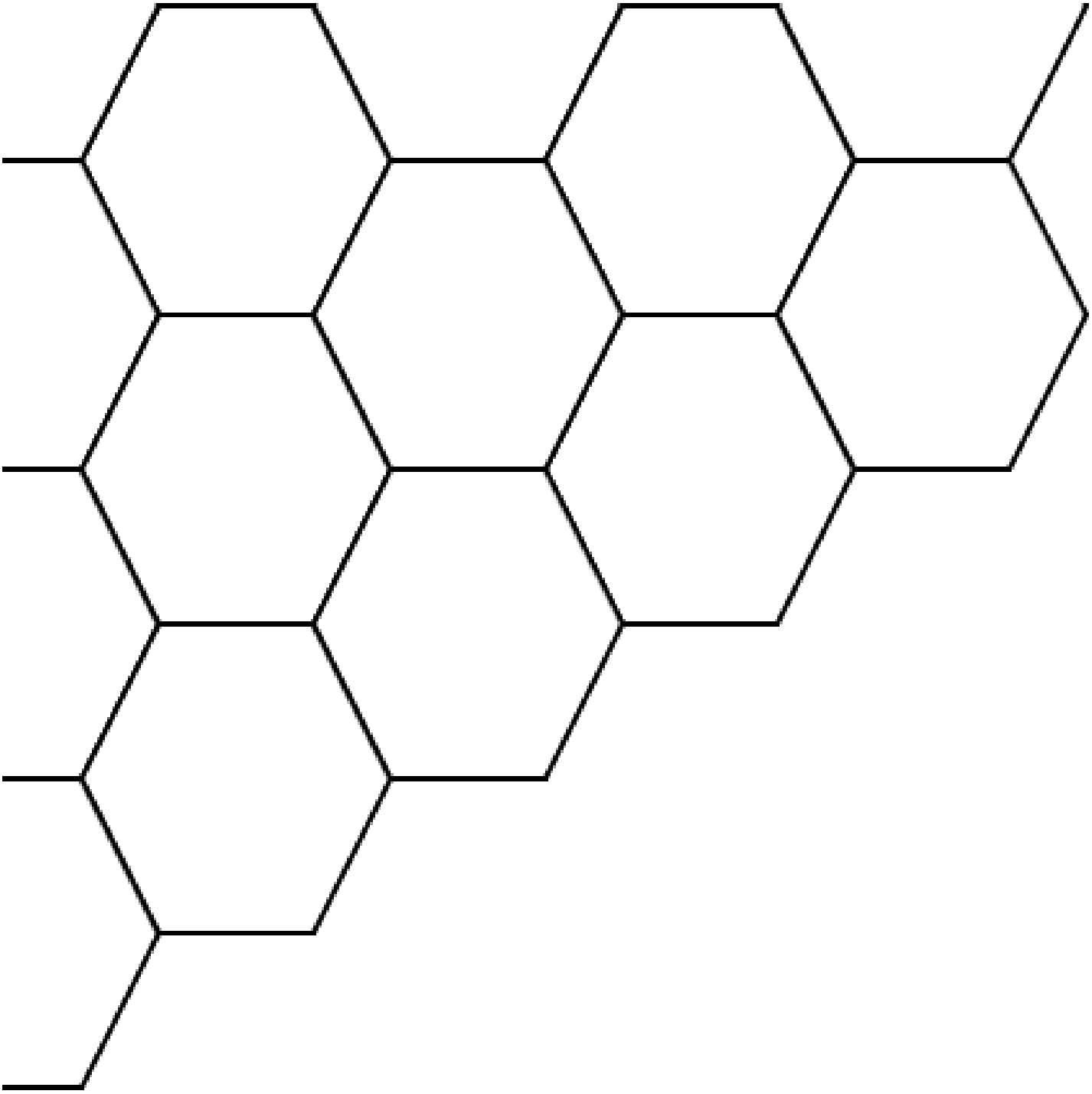
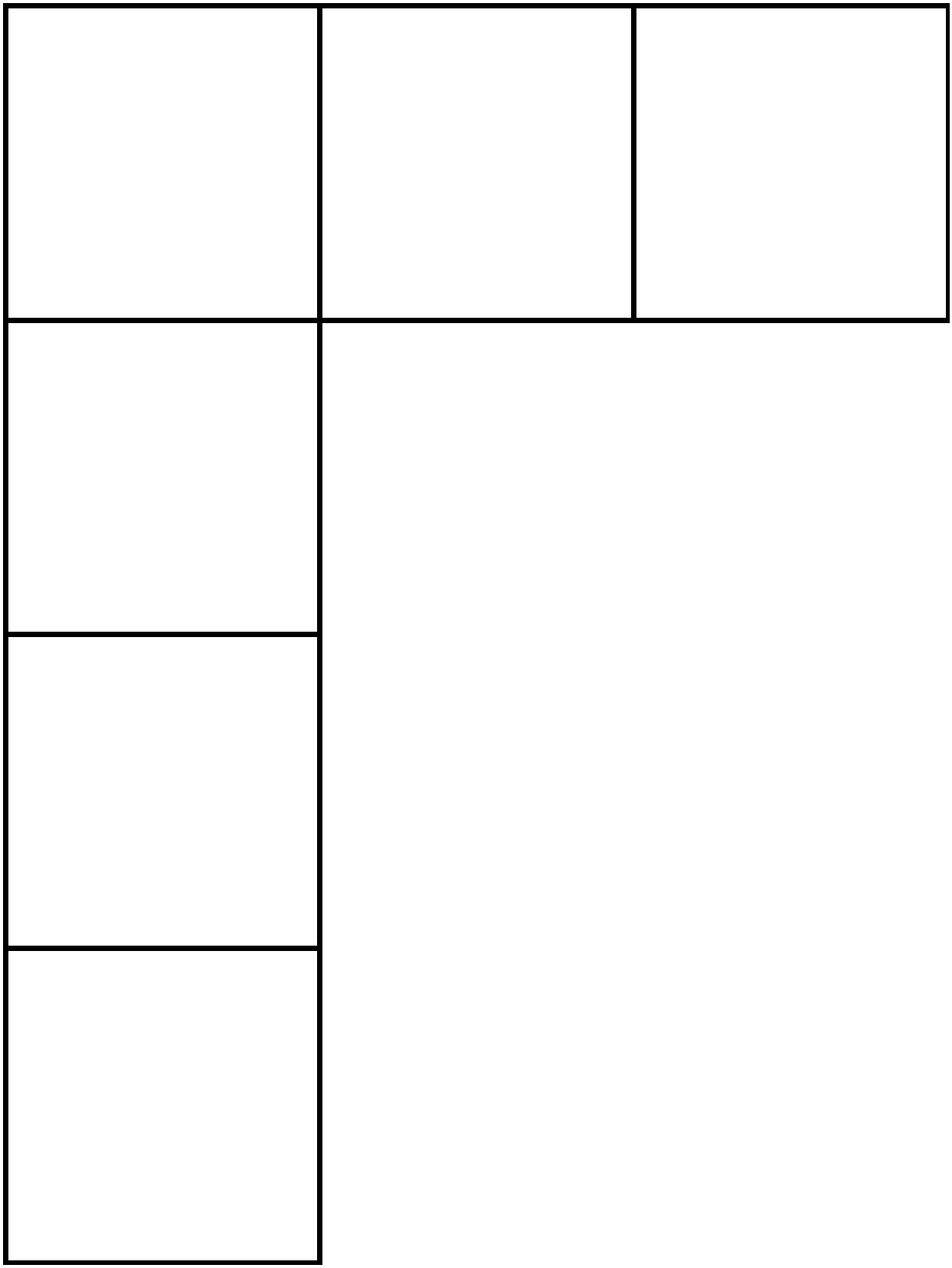


6.A Gameboard Template (Option 3)



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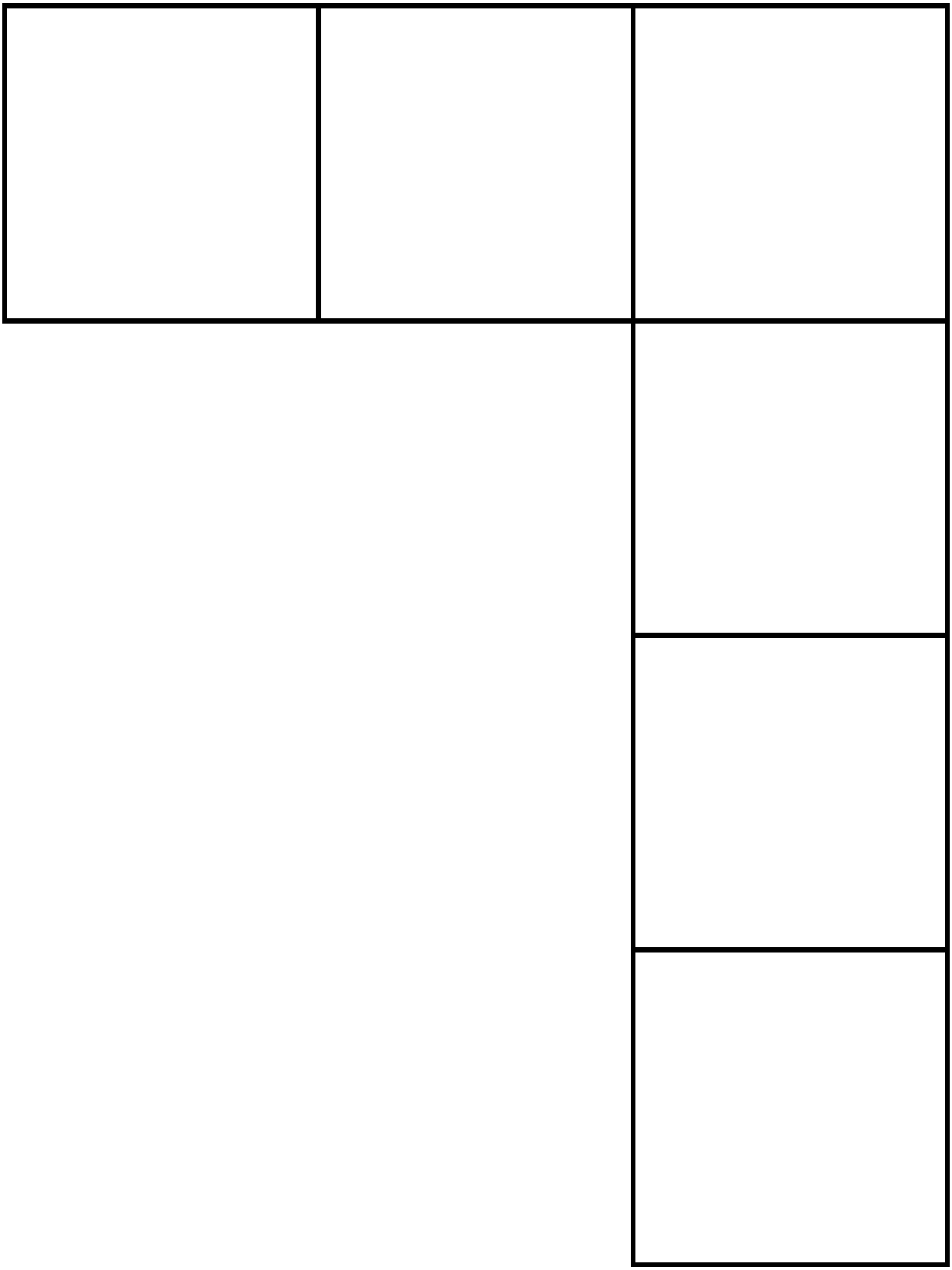

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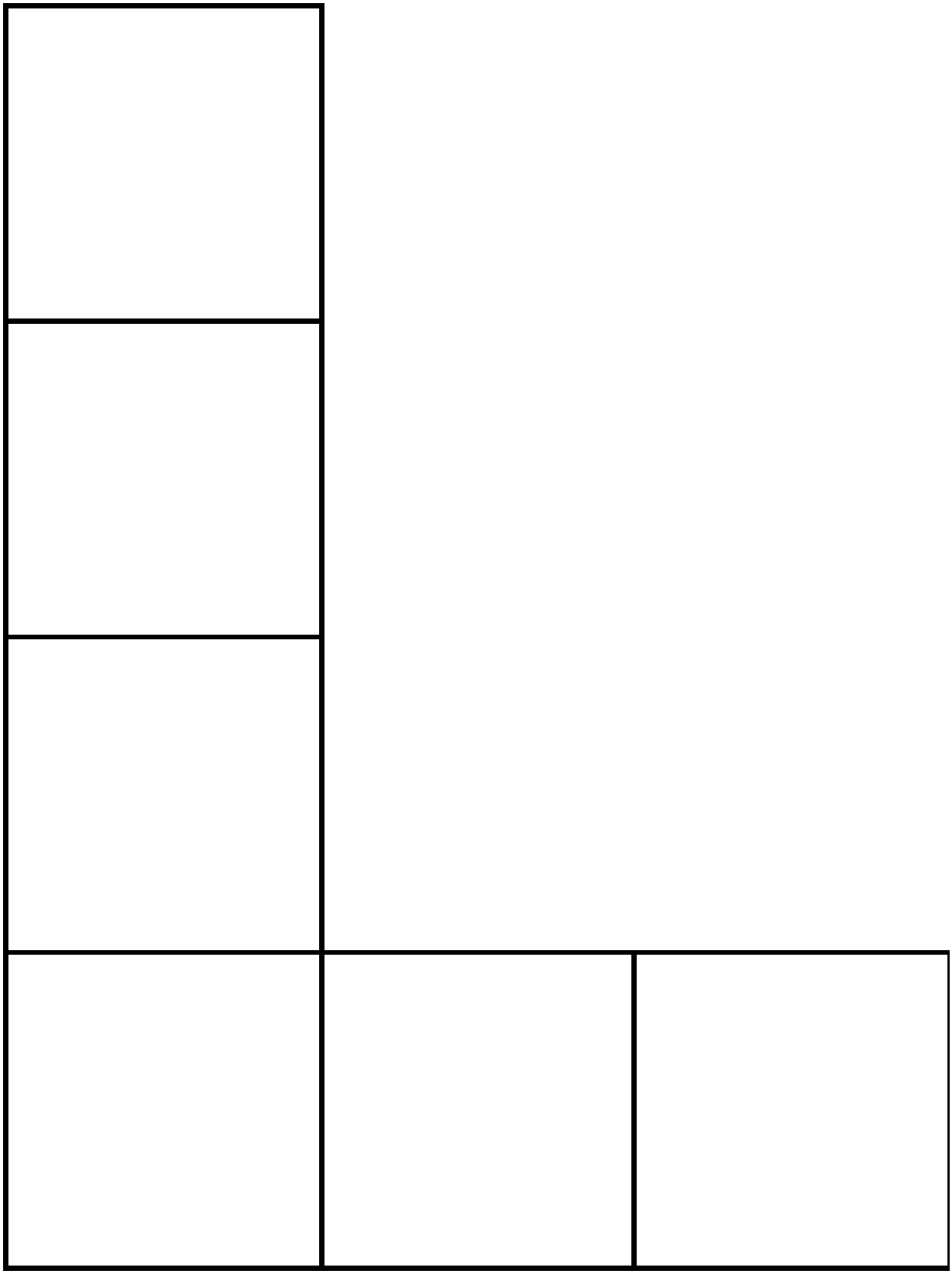

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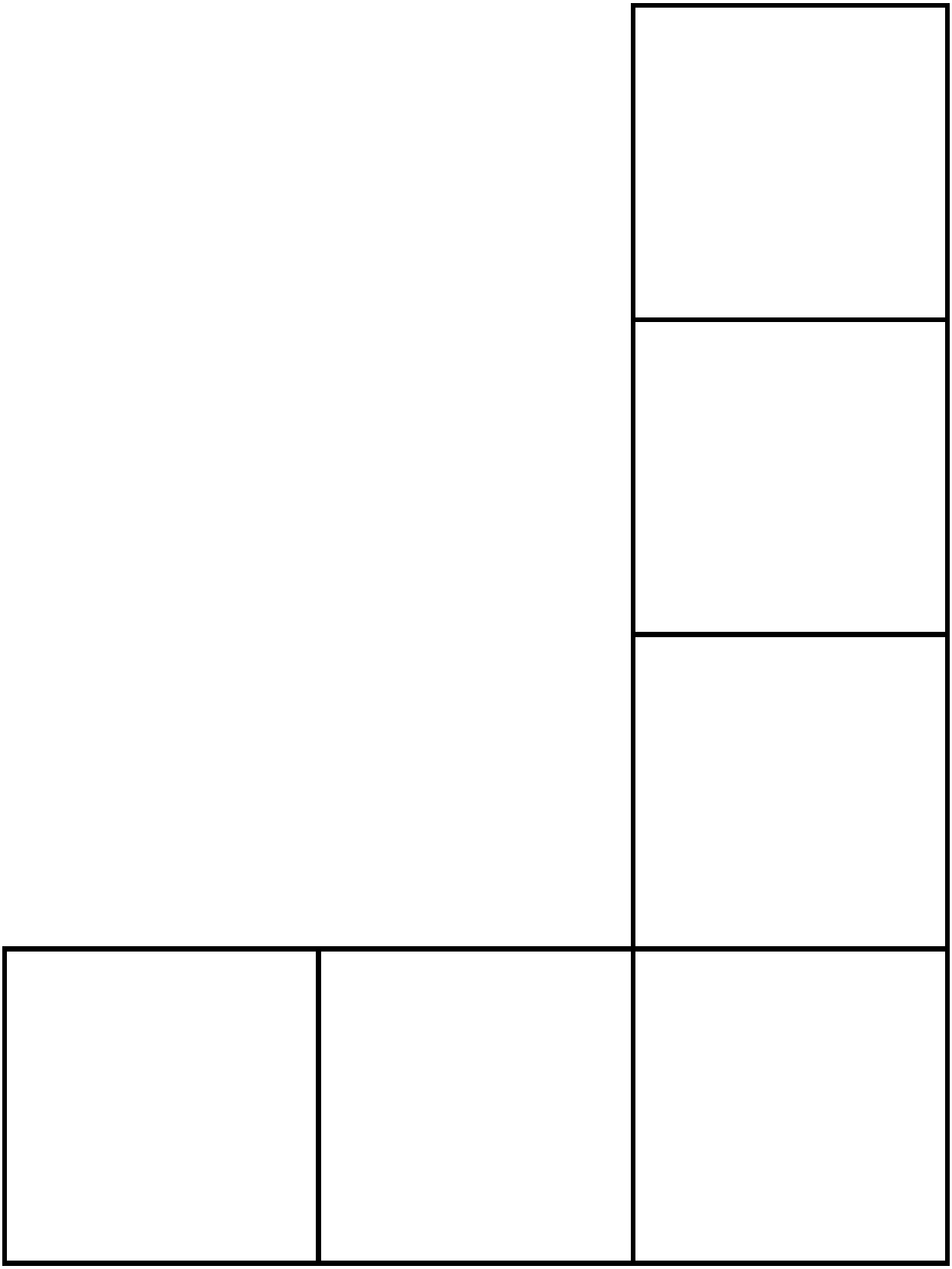
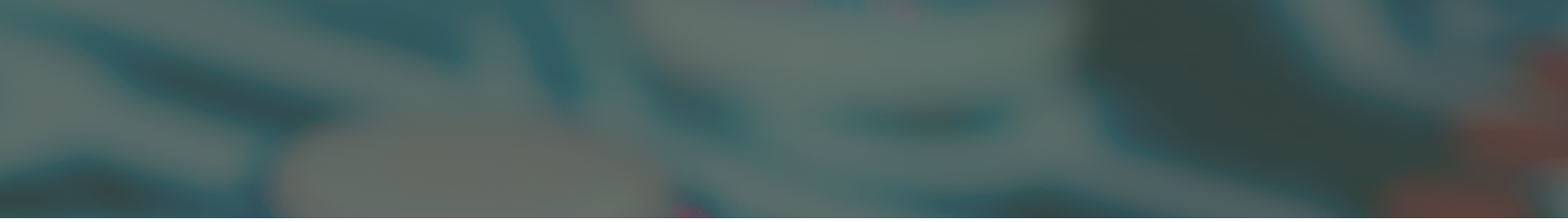


Name_____ Date_____ Period _____

6.B Testing Reflection 1

Analyze your solution based on:	The results from your tests	The expected results based on what you learned before planning	whether or not your solution addressed the criteria and met the constraints
What went well?			
What needs improvement?			

Based on your analysis of your test results, the expected results, and the criteria and constraints, what improvements to your solution do you want to make and why?



LESSON SEVEN:

Lesson Objectives
Students will be able to:
- Evaluate other teams' designs using a rubric.
- Redesign their solution to the engineering challenge using evidence and feedback from other groups.
- Create a publishable quality version of their instructions for the client.

Time Required
Two 45-minute lessons

Materials
Per classroom:
- EDP Poster
- Construction paper
- Pipe cleaners
- String
- Popsicle sticks
- (2) Glue Bottles
- (2) Glue Sticks
- (2) tape
- (optional) materials from home

Per group (3 per group):
- Foldable gameboard base
- Box of colorful pens
- micro:bit kit

Per student:
- EDP slider w/ jumbo paperclip
- Laptop or equivalent device
- Engineering notebook

Key Terms
evidence-based reasoning, redesign, beta test, feedback, final draft

Lesson Summary
Students will playtest other groups games and evaluate the quality of other games using rubric that focuses on context, constraints, and playability. Then, students will redesign their games and instructions after receiving feedback from their peers. Students will use evidence-based reasoning to justify their redesign decisions. Students will receive another client memo about presentation requirements.

Lesson Background
Teacher Background
Redesign: Redesigning is a necessary piece in the engineering design process that can often be overlooked due to time constraints. Make sure you leave time for teams to reflect on the testing process so they can improve their solution to better meet the client's needs.

Before the Activity
- Decide if you want to randomize the testing groups or assign specific groups to test each other's designs.
- Make copies of the duplication masters in the following amounts:
  - 1 per group) 7.A Evaluation Rubric, 7.E Client Communication Requirements
  - (1 per student) 7.B Testing Reflection 2, 7.C Redesign Prompts, 7.D Client Memo 5

Classroom Instruction
Introduction
1. **Revisit the engineering challenge. Ask:** *What is the client's problem? What are the criteria and constraints we have been given? What are some of the things we have learned that we are using to best solve the client's problem?*
2. **Identify where they are in the EDP. Ask:** *What stage of the EDP will we work through today? (Test)*

Activity
3. **Prepare groups for testing. Say:** *Compared to the self-evaluation alpha testing you did in the previous class, beta testing will require more detailed evaluation criteria.* Hand out an 7.A Evaluation Rubric to each group and have them fill out the top section. Before testing games make sure the groups

are aware of the specific end users their game is intended to be used by or marketed for. If needed, have students revisit 3.C Client Memo 2 so they can write the information about their design brief on their evaluation form which will be used by another team during the testing process. Have students set up their game and all components so they are ready for testing. Give them some time to make sure their micro:bit functions the same as it did in the last class. **Say:** *After I tell you which team's design you will be testing, you will move to their spot where you should find their game board, instructions, coded micro:bit, and any additional pieces all ready to go.*
NOTE: If the micro:bits are shared between class sections, groups will need to redownload their code onto the micro:bit at the beginning of the lesson.

4. **Playtest other groups' games.**
5. **Evaluate other groups' games using rubric.** Make sure students who are playtesting write their names on the bottom of the evaluation form they are filling out. Based on constraints, criteria, and clarity of instructions...
6. **Testing reflection.** Have students individually complete the test solution ideas prompts then share their responses with their teams.
7. **Planning for redesign.** Have groups plan their redesign using data from alpha and beta testing.
8. **Allow time for redesign.** Students will need to adjust the game mechanics and redraft their instructions.
9. **Create a publishable copy of instructions.**

Closure

10. **Connect back to the engineering design challenge. Ask:** *What is our client's problem? How are we incorporating the criteria and constraints in your solutions?*
11. **Revisit the EDP. Ask:** *What phase(s) of the EDP did we spend time on today?* (Test). **Ask:** *What phase will be working on next time?* (Decide)

Standards Addressed

7.IPS.1, HS.IPS.1, 7.IPS.2, HS.IPS.2, 7.IPS.3, HS.IPS.3

Assessment

Activity Embedded Assessment

Pay attention to group discussions as they evaluate other teams' games to gauge their understanding of the trade-offs to consider as part of engineering design.

Post-Activity Assessment

Duplication Masters

7.A Evaluation Rubric
7.B Testing Reflection 2
7.C Redesign Prompts
7.D Client Memo 5
7.E Client Communication Guidelines

Name_____ Date_____ Period _____

7.A Evaluation Rubric

Game: _____ **Design brief: _____**

Game Designers: _____

Criteria	3 points: Meets all expectations.	2 points: Meets most expectations.	1 point: Partially meets expectations.	0 points: Does not meet expectations
Overall Design				
Materials: reused old game template and recycled materials				
Creativity: design is unique with a clear visual theme				
Function: board game is durable and playable				
End users: game is intended for target audience				
Game Instructions				
Purpose: identifies the overall goal of the game				
Background: game pieces, board, and electronic components are explained				

Name_____ Date_____ Period _____

Vocabulary: word choice intended for the target audience				
Structure: logical flow of steps				
Content: includes necessary information				
Modes: includes images or figures when needed				
Microelectronics Components				
Software: micro:bit performs the function described in the rules				
Utility: the micro:bit device is easy to use				

Evaluation Team: _____

Name_____ Date_____ Period _____

7.B Testing Reflection 2

Analyze your solution based on:	The results from your tests	The expected results based on what you learned before planning	whether or not your solution addressed the criteria and met the constraints
What went well?			
What needs improvement?			

Based on your analysis of your test results, the expected results, and the criteria and constraints, what improvements to your solution do you want to make and why?

Name_____ Date_____ Period _____

7.C Redesign Prompts

Directions: Fill in the table regarding the overall quality of your solution.

Analyze your redesign based on:	The results from your redesign tests	The expected results based on what you learned before redesigning	whether or not your solution addressed the criteria and met the constraints
What went well?			
What needs improvement?			

1. **Did your redesign improve your solution? Why or why not?**

2. **If you could do another redesign, how would you try to improve your solution?**

7.D Client Memo 5

Dear Engineers,

Now that you have completed alpha and beta testing, it is time to pitch your game to GEM executives. Your presentation must use the guidelines that are attached to this memo. This is your opportunity to convince GEM to manufacture your game.

Thank you for your help. We are eager to see your game designs.

Sincerely,

Rubi Gonzalez

Rubí Gonzalez
Engineering Outreach Coordinator
Games, Electronics, and Motivation (GEM)

7.E Client Communication Guidelines

- □ Students introduce themselves
- □ Students summarize the client's problem including criteria and constraints
- □ Students explain why it is important to reduce screentime by bridging the gap between electronics and board games
- □ Students describe their solutions to the problem
- □ Students show their prototype, including instructions
- □ Students justify their prototype decisions
- □ All team members have a role in the presentation
- □ Students demonstrate in-depth knowledge of the topics of micro:bits, game design concepts, and informative writing
- □ Students thank the client for their time

LESSON EIGHT:

Lesson Objectives
Students will be able to:
- Compose an argumentative presentation.
- Reflect on engineering, writing processes, and learning.

Time Required
Two 45-minute lessons

Materials
Per classroom:
- EDP Poster

Per group (3 per group):
- Micro:bit, battery case, (2) AA batteries, USB to micro-USB cord

Per student:
- EDP slider w/ jumbo paperclip
- Laptop or equivalent device
- Engineering notebook

Standards Addressed
5-6.W.4
7.W.4
9-10.W.4

Key Terms
client, presentation, argumentative, evidence-based reasoning, justification, criteria, constraints

Lesson Summary
Students will argumentatively present their final design to the client. Students will demonstrate evidence-based reasoning to justify their design choices. Students will submit an individual unit reflection.

Background
Teacher Background
Communicating to the client: Communication is one of the most important skills for engineers. They need to be able to share their designs with an audience who may not be familiar with the problem and engineers have to justify their recommendations using evidence. In this lesson, students will be making presentations to convince the client that their board game should be manufactured by their company. The teacher can choose from a variety of presentation options based on the materials and technology that are available. Presentations may be live, in-person or video recorded. Alternatively, the teacher may choose to have students write a persuasive letter to the client from their team with the same information they would have included in presentation form.

Argumentative Writing: Students will need to use evidence and logic to support their design idea. In this lesson, students will be "pitching" their idea to the client so it is important for them to understand how to make a good argument. Elements you may want to emphasize for students include: clearly presenting their main argument (the design they want the client to produce), providing supporting evidence for why the client should choose their design (including potential negative aspects and suggestions for redesign), and explaining how their solution fully addresses the client's problem.

Before the Activity
- Make copies of the duplication masters in the following amounts:
  - (1 per student) 8.B Content Post-Assessment, 8.D Client Memo 6
  - (2-5 per student depending on the number of groups to evaluation) 8.A Presentation Evaluation

    NOTE: Students can complete the evaluations of other teams in groups or individually
- (Optional) prepare a presentation template so students can save time and focus on the content of the slides

- Before distributing duplication master 8.D Client Memo 6, it is recommended that the teacher adds feedback specific to the students' presentations. If the teacher chooses this option, they will need to treat 8.D Client Memo 6 as a template and make a new version with specific feedback added after the first sentence of the body of the letter.

Classroom Instruction

Introduction

1. **Tie to the engineering challenge. Say:** *We are almost done with the engineering design challenge!* Discuss the engineering challenge as a class. **Ask:** *What was our client's problem? What were the criteria and constraints of the problem? How are we considering our end users as we finalize our designs?*
2. **Identify where they are in the engineering design process. (Decide) Ask:** *What stage of the design process were you working through in the previous class?* **Say:** *Throughout the entire engineering design process, we have been working in teams and communicating within your teams and with other teams. Now you need to communicate to the client, Rubí, so that they know about your board game design and how it meets their needs.*

Activity

3. **Review the presentation requirements.** Revisit 7.E Client Communication Requirements as a class to make sure students know what information the client expects to see in their presentations.
4. **Emphasize argumentative writing. Say:** *As you work on your presentations to the client, you will need to use argumentative writing techniques. This means you will have to explain your design then provide evidence for why the client should consider bringing your board game idea back to their company for mass production. In other words, your team needs to convince the client why your design is the best.*
5. **Prepare group presentations for the client.** If the teacher has prepared a presentation template, distribute the template to students. Allow students time to work in their groups to prepare their slides including creating any visuals, rehearsing demonstrations, and filming videos if not presenting live, in-class.

Assessment

Activity Embedded Assessment

Use the 7.E Client Communication Requirements or the 8.A Presentation Evaluation to assess how well students presented the important information as a group.

Post-Activity Assessment

Use the 8.C Content-Post Asesment key to evaluate student progress throughout the unit by comparing their responses on the 1.A Content Pre-Assessment and 8.B Content Post-Assessment.

Duplication Masters

8.A Presentation Evaluation
8.B Content Post-Assessment
8.D Client Memo 6

Educator Resources

8.C Content Post-Assessment Key

6. **Present to the class.** Have students evaluate whether groups met criteria and constraints for the client using the 8.A Presentation Evaluation forms.

   NOTE: This can be used as an evaluation tool or simply to provide feedback to groups before they complete their individual reflections on the design challenge.
7. **Provide feedback to teams.** Make sure students pass out their completed evaluation forms to each design team. Give each team a few minutes to discuss the feedback. Although they won't be redesigning again, this is a good example of how professional engineers iteratively solve problems and incorporate feedback in their designs.
8. **Individual reflection.** Have students reflect on the EDP, the engineering challenge, writing processes, and what they learned throughout the unit in their engineering notebooks.

Closure

9. **Identify where they are in the engineering design process. (Communication) Ask:** *What stage of the design process were we working on today?* Make sure students know that while they did Decide on their team's design, they were communicating their designs to the class and client. Discuss why communication with the client is necessary to engineering design.
10. **Revisit engineering design challenge.** Discuss the problem, how teams justified their design decisions, important characteristics of informative writing, and how students considered criteria and constraints when solving the problem.
11. **Provide feedback from the client.** Hand out 8.D Client Memo 6 to students. Read the memo as a class and answer any questions students have about their presentations or solutions.
12. **Complete the end of unit assessment.** Hand out the 8.B Content Post-Assessment and have students complete this individually. It is important that students do not help each other. They should also not be referring back to the pre-assessment they completed at the beginning of the unit.

Final Boss

Name_____ Date_____ Period _____

8.A Presentation Evaluation

Names of Game Designers Presenting:

Requirements	Feedback
Students introduce themselves	
Students summarize the client's problem including criteria and constraints	
Students explain why it is important to reduce screentime by bridging the gap between electronics and board games	
Students describe their solutions to the problem	
Students show their prototype, including instructions	
Students justify their prototype decisions	
All team members have a role in the presentation	
Students demonstrate in-depth knowledge of the topics of micro:bits, game design concepts, and informative writing	
Students thank the client for their time	

Name of Evaluator:

Names of Game Designers Presenting:

Requirements	Feedback
Students introduce themselves	
Students summarize the client's problem including criteria and constraints	
Students explain why it is important to reduce screentime by bridging the gap between electronics and board games	
Students describe their solutions to the problem	
Students show their prototype, including instructions	
Students justify their prototype decisions	
All team members have a role in the presentation	
Students demonstrate in-depth knowledge of the topics of micro:bits, game design concepts, and informative writing	
Students thank the client for their time	

Name of Evaluator:

Name_____ Date_____ Period _____

8.B Content Post-Assessment

Part 1 Directions: Circle True or False. Explain in your own words how you know the answer. It is okay if you don't know the answers!

True or False	Statement
1. T or F Explain:	*The following sentences use the informative writing style:* Dogs are great pets because they are loyal to their owners. They are also playful and like to have fun.
2. T or F Explain:	You are using **logical flow** in your writing when you use transition words like *first, next,* and *finally.*
3. T or F Explain:	Sequencing is **not** important to coding.
4. T or F Explain:	A good example of informative writing includes **evidence**.
5. T or F Explain:	Micro:bits can be used in your home.
6. T or F Explain:	Argumentative writing and informative writing are the same.
7. T or F Explain:	Evidence-based reasoning is **not** important when designing something.

Name_____ Date_____ Period _____

8.B Content Post-Assessment

Part 2 Directions: Answer the following questions. You can use drawings or write in the language most comfortable for you if you get stuck. It is okay if you don't know the answers!

8. What does the term, "microelectronics" mean?

9. How are microelectronics used in the field of language arts?

10. What jobs would you be interested in that use microelectronics?

11. Provide one example of how microelectronics is used in that job.

8.C Content Post-Assessment Key

Part 1 Directions: Circle True or False. Explain in your own words how you know the answer. It is okay if you don't know the answers!

True or False	Statement
1. T or F	*The following sentences use the informative writing style:* Dogs are great pets because they are loyal to their owners. They are also playful and like to have fun.
Explain:	These sentences present consice information about dogs. The second sentence references the first with the word "also", providing logical flow.
2. T or F	You are using **logical flow** in your writing when you use transition words like *first, next,* and *finally.*
Explain:	Logical flow is the order in which information is presented in a piece of writing and it is the way in which the elements (paragraphs, sections, sentences) are connected to one another. These connections are often made using transition words.
3. T or F	Sequencing is **not** important to coding.
Explain:	Computers will run a code in the order that it is written. If sections of a code are not written in the right sequence, the code may result in a different output than intended or it may not run at all.
4. T or F	A good example of informative writing includes **evidence**.
Explain:	Providing evidence is important to communicating information to the reader in the informative writing style. This evidence separates informative writing from other forms which include opinions instead of facts.
5. T or F	Micro:bits can be used in your home.
Explain:	There are many correct answers to this question, but a few examples include a security system, a smart thermostat, or to measure energy usage.
6. T or F	Argumentative writing and informative writing are the same.
Explain:	The goal of argumentative writing is to present an opinion or defend an idea while the goal of informative writing is to communicate information or facts.
7. T or F	Evidence-based reasoning is **not** important when designing something.
Explain:	Evidence-based reasoning is important because it provides a justification for the decision that was made.

8.C Content Post-Assessment Key

Part 2 Directions: Answer the following questions. You can use drawings or write in the language most comfortable for you if you get stuck. It is okay if you don't know the answers!

8. What does the term, "microelectronics" mean?

   Student answers may vary, but the formal definition of microelectronics is the design, manufacture, and use of microchips.

9. How are microelectronics used in the field of language arts?

   There are many answers to this question, but examples include Boolean logic in library searches, online news and media websites that share informative or argumentative texts, digital copies of books, and translation devices which allow for communication across language barriers.

10. What jobs would you be interested in that use microelectronics?

    Students' answers will vary based on interest. Credit may be given as long as at least one job example is provided.

11. Provide one example of how microelectronics is used in that job.

    Students' answers will vary based on interest. Credit may be given as long as at least one job example is provided with their logic behind how that job uses microelectronics.

8.D Client Memo 6

Dear Engineers,

I received your presentations this morning and have reviewed them. Your recommendations will be extremely helpful as the divisions start to use focus groups to take your designs to the next stage of production. I anticipate some of your ideas will help reduce screentime usage and help kids get excited about playing board games with their families.

Thank you for your dedication to this engineering design challenge and for all of the hard work that you did for my company. I hope to have an opportunity to work with you again in the future.

Sincerely,

Rubi Gonzalez

Rubí Gonzalez
Engineering Outreach Coordinator
Games, Electronics, and Motivation (GEM)