6th Grade SYSTEMS CHALLENGE

Arcade Entrepreneur

Teacher Facilitation Guide

Duration: ~ 10 60-Minute Class Periods

CHALLENGE OVERVIEW

Students return to Pixel Palace Arcade — the struggling neighborhood arcade they investigated in the Data Challenge — to take on a hands-on engineering problem. Pat "Pac" Manning, the arcade owner, has written a follow-up letter: Storm-the-Castle, the catapult-based game on the Loser list, is hemorrhaging money. Pat wants the team to redesign the landing zone so the game wins back customers without giving away too many big prizes.

Working in groups of three, students explore odds of winning by playing simple games of skill, learn how a torsion catapult works, establish a careful experimental procedure, collect launch data, design a landing zone that meets Pat's win-percentage requirements, validate the design through more testing, calculate profit for the redesigned game, and share their work in a gallery walk. The unit sets up the Design Challenge that follows, in which students will design a brand-new arcade game.

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

- Calculate the odds of winning a game of skill from observed data
- Identify the parts of a torsion catapult and explain how it stores and releases energy
- Establish and follow a consistent experimental procedure to reduce variability in data
- Use launch data to design a landing zone that meets specific win-percentage targets
- Validate a design through additional testing and revise based on the data
- Calculate revenue, cost, and profit for a redesigned arcade game
- Communicate a data-backed design through a one-page poster and structured peer feedback

MODULE STRUCTURE

Activity 1 — Pat's Follow-Up & Odds of Winning (Day 1)

Activity 2 — Meet the Catapult & Force Diagram (Day 2)

Activity 3 — Launch Activity 1: Establishing a Procedure (Day 3)

Activity 4 — Launch Activity 2: Data Collection (Day 4)

Activity 5 — Target / Landing Zone Design (Day 5)

Activity 6 — Validation Testing (Day 6)

Activity 7 — Prizes and Profit (Day 7)

Activity 8 — Poster Build (Day 8-9)

Activity 9 — Gallery Walk & Cliffhanger (Day 10)

MATERIALS

Pitsco torsion catapult kits — recommended one per group of 3 (about 8–10 for a typical class). If you are unable to purchase and build 8-10 catapults, a fleet of 4–5 catapults works with a rotation schedule.

Pompoms for projectiles

Safety glasses for every student

Butcher paper for measuring launches

Graph paper (large 1-inch grid for class chart; standard for student work)

Markers, sticky labels, sticky arrows, calculators

Sample-games kit for Activity 1 (ring toss, bean bag toss, bounce cup, slide-to-target — see Companion Handouts)

Handout 1: Follow-Up Request for Proposal

Handout 2: Odds of Winning Data Sheet (one per group per launch session)

Handout 3: Catapult Force Diagram

Handout 4: Launch Data Recording Sheet

Handout 5: Landing Zone Design Sheet

Handout 6: Validation Launch Data Recording Sheet

Handout 7: Validation Equations Sheet

Handout 8: Arcade Prize Menu and Profit Calculation Sheet

Handout 9: One-Page Poster template (printed on 11×17 or 24×18 paper)

Handout 10: Gallery Walk Feedback Slip

KEY VOCABULARY

Odds of winning: the share of plays that result in a win, often expressed as a percentage. Example: if a game is won 1 out of every 10 plays, the odds of winning are 10%.

Torsion / Tension: twisting force / pulling force. The Pitsco catapult stores energy in a stretched rubber band (tension) that snaps back when released, illustrating Newton's third law of motion.

Procedure: the consistent steps you follow during an experiment so every trial is comparable.

Variability: spread or inconsistency in data. Less variability means more reliable predictions.

Precision: how repeatable your results are. Tightly clustered data points are precise.

Tolerance: the acceptable range for a measurement or design dimension.

Validation: testing a design to confirm it actually meets the requirements.

STANDARDS ALIGNMENT

NGSS Engineering Design

MS-ETS1-2: Evaluate competing design solutions using a systematic process
MS-ETS1-3: Analyze data from tests to determine similarities and differences among design solutions
MS-ETS1-4: Develop a model to generate data for iterative testing and modification

Science and Engineering Practices

Practice 3: Planning and carrying out investigations
Practice 4: Analyzing and interpreting data
Practice 5: Using mathematics and computational thinking

Common Core Standards for Mathematical Practice

SMP 1: Make sense of problems and persevere in solving them
SMP 2: Reason abstractly and quantitatively
SMP 4: Model with mathematics
SMP 5: Use appropriate tools strategically
SMP 6: Attend to precision
SMP 8: Look for and express regularity in repeated reasoning

See the Arcade Entrepreneur Systems Challenge Planning Guide for complete alignment details.

ACTIVITY 1

Pat's Follow-Up & Odds of Winning

Essential Question: What does it mean for a game to have the right odds of winning?

TIME
~50 min

Students reconnect with Pat "Pac" Manning and the Pixel Palace context from the Data Challenge. Pat has written a follow-up RFP: Storm-the-Castle, the catapult-based game students flagged on the Loser list, is still losing money. Pat wants the team to redesign the landing zone so the game wins back customers without giving away too many big prizes. Students then rotate through four simple games of skill, recording wins and losses and calculating odds of winning — the foundation for the design work to come.

SETUP & MATERIALS

- Print one Pat's Follow-Up RFP per group (also project on the screen).
- Set up four sample-games stations around the room: Ring Toss, Bean Bag Toss, Bounce Cup, and Coin Slide.
- Print one Odds of Winning Data Sheet per student.
- Decide group composition (recommended: groups of 3). The same groups will work together for the entire unit.

Part 1 — Pat's Follow-Up Letter: 10 min

Open by reconnecting with the Data Challenge. Remind students of Pat, Pixel Palace, and the recommendations they made — specifically the bucket sort that put Storm-the-Castle in the Loser column. Then read Pat's follow-up RFP aloud or hand out copies. The full letter is reproduced in Appendix A. The short version:

- Pat doesn't want to give up on Storm-the-Castle — it's the only catapult game in the arcade and players who do try it have a great time.
- The targets are too hard to hit. Almost no one wins. Pat needs a new landing zone.
- Requirements: about 40% of players should win a small prize. About 10% should win a large prize. The game must make at least $50 per day in profit.
- The team will use a real torsion catapult — the same kind used in the actual game — to test their designs.

DISCUSSION PROMPTS — PAT'S NEW PROBLEM

- What did our team recommend to Pat at the end of the Data Challenge? Did Pat take all of our advice?
- Why might Pat want to save Storm-the-Castle instead of just removing it?
- What do you think a "good" arcade game looks like? Should it be easy or hard to win?

Part 2 — Sample Games Station Rotation: 25 min

Divide the class into their groups of three. Groups rotate through the four sample-game stations (Ring Toss, Bean Bag Toss, Bounce Cup, Coin Slide) for about 5–6 minutes each. At each station, each student plays the game 5 times and records wins and losses on the Odds of Winning Data Sheet.

Sample Game Station Set-up

Station	Materials	Setup & Win Rule
1. Ring Toss	3–4 plastic rings; 1 standing peg or empty water bottle	Place the peg about 6 feet from the throwing line. Each student tosses 5 rings. WIN = ring lands on the peg.
2. Bean Bag Toss	5 bean bags; cardboard with a 6-inch target hole, propped at an angle	Place the target board about 8 feet from the throwing line. Each student tosses 5 bean bags. WIN = bag goes through the hole.
3. Bounce Cup	5 ping-pong balls; 1 plastic cup	Place the cup on a hard surface 3 feet from the bouncing line. Each student bounces 5 balls toward the cup. WIN = ball bounces once and lands in the cup.
4. Coin Slide	5 quarters or poker chips; masking tape to mark a target rectangle	Mark a 6-inch by 6-inch target box on a smooth table. Each student slides 5 coins from a starting line 3 feet away. WIN = coin stops fully inside the box.

TEACHER TIPS:

STATION DIFFICULTY

Aim for a mix: at least one station should be easy (most plays win) and at least one should be hard (most plays lose). This makes the odds-of-winning discussion in Part 3 of Activity 1 much richer.

KEEP IT MOVING

Use a timer with a clear chime to signal rotations. Set a quick rule (“5 plays each, count, write, switch”) and circulate to catch groups that are over-thinking the rules. The goal is enough data to calculate odds — not perfect scoring.

Part 3 — Odds Calculations & Discussion: 10–15 min

Back at their tables, students calculate odds of winning for each game on the Data Sheet. Use the formula:

Odds of winning = (number of wins ÷ total plays) × 100%

Lead a closing discussion that connects what students just experienced to Pat's problem.

DISCUSSION PROMPTS — WHAT THE ODDS MEAN

- Which games were easy to win? Which were hard?
- Which games would you want to play at an arcade? Why?
- What would the right odds of winning be for a good arcade game? Why?
- Imagine Pat charged $1 to play one of our station games. Which one would Pat lose money on? Which would Pat make money on? Why?

ACTIVITY 2

Meet the Catapult & Force Diagram

Essential Question: How does a torsion catapult store and release energy?

TIME
~50 min

Students get hands-on time with the pre-built Pitsco torsion catapult, learn the parts and safety rules, and then build a force diagram as a group — labeling the parts, adding arrows for the tension force and projectile motion, and identifying the action/reaction pair from Newton's third law. The class compares group diagrams to build a consensus understanding.

SETUP & MATERIALS

- Pre-build the Pitsco catapults before the unit begins. Build instructions: see catapult_user_guide.pdf from Pitsco. (Optional: assign a few kits to advanced students or do this as a STEM-club activity in advance.)
- Print one blank Catapult Force Diagram per group.
- Print one set of part-name labels per group (Frame, Arm, Twisted String, Axle, Trigger, Scoop) on small label stickers — students will affix them to the diagram. Alternatively, have students write part-names on blank labels.
- Have arrow stickers, colored markers, and projectiles ready.
- Set up a clear launch area along one wall with a measured backstop (or butcher paper).
- ROTATION NOTE: If you have fewer catapults than groups (e.g., 4 catapults for 8 groups), split each part of the activity into two waves. While one wave handles the catapult, the other wave works on the force diagram template. Switch halfway.

Part 1 — Meet the Catapult & Safety: 15 min

Demonstrate one full launch to the class. Stop after the launch and walk through the safety rules:

- Safety glasses on, every time, every person.
- The only allowed projectile is pompoms — no pencils, no erasers, no anything else.
- Catapult arm points only at the agreed launch area. Never at people.
- One person launches at a time. The other group members are observers/recorders, not in the launch zone.

Then give each group 5–7 minutes to handle their catapult, identify the parts by sight, and do 2–3 practice launches so everyone in the group has tried it once.

Part 2 — Force Diagram: 25 min

Hand each group a blank Catapult Force Diagram template. Working together, groups do four steps:

1. Label the parts. Using sticker labels or markers, label the following parts of the diagram: Frame, Arm, Twisted string, Trigger, Scoop.
2. Add force arrows. Using colored markers, add arrows that show: the pull-back force on the arm, the tension stored in the stretched rubber band, the release direction when the arm snaps forward, and the projectile's trajectory.
3. Annotate the energy story. Next to each arrow, write a short caption (e.g., "Pull-back force loads the catapult"; "twisted string stores tension energy"; "Arm releases — energy transfers to the clay ball").
4. Mark Newton's 3rd Law. Put a star anywhere on the diagram where there is an action/reaction pair. Most groups should land on the twisted string: pulling back the arm (action) twists the string more, which then pulls the arm forward when released (reaction).

TEACHER PROMPTS WHILE GROUPS WORK

Vocabulary in everyday terms: Tension = pulling force. Torsion = twisting force. The Pitsco catapult uses tension (the stretched rubber band) to store energy, while historical catapults often used torsion (twisted ropes). Elasticity is the material's ability to spring back to its original shape.

If a group is stuck: "What is your hand doing to the rubber band when you load the catapult? What is the rubber band doing back?" That's the Newton's 3rd Law pair.

If a group finishes early: Ask them to predict — if Pat used a stiffer (harder to stretch) rubber band, how would the launch distance change? Why?

Part 3 — Class Consensus Diagram: 10 min

Have each group post their force diagram on the wall. Quick gallery walk: students look for the best labels and clearest arrows across groups. As a class, build a single consensus diagram on the board using the strongest elements from each group.

DISCUSSION PROMPTS — WRAP UP

- What is the same on every group's diagram? What is different?
- Where exactly is the energy stored before the launch?
- What would happen if the rubber band were stretched twice as far? Half as far?
- Why does the launch direction stay the same every time but the distance changes?

ACTIVITY 3

Launch Activity 1: Establishing a Procedure

Essential Question: Why does following a procedure matter when collecting data?

TIME
~50 min

Students conduct their first launch trials with no agreed-upon procedure, see firsthand how inconsistent procedures create wildly variable data, and then work as a class to establish a common launching procedure that everyone will use for the rest of the unit. This activity surfaces the concept of variability and sets up trustworthy data collection in Activity 4.

SETUP & MATERIALS

- Each group needs a catapult, projectiles (pompoms), and graph paper (one large sheet for the group with the catapult position marked at the origin).
- Tape a large class-wide chart paper (with a coordinate grid) to one wall — groups will transfer their launch data onto it for the class discussion.
- Have a metric ruler or measuring tape at each catapult station for marking landing positions.
- ROTATION NOTE: With fewer catapults, alternate groups between launching and recording on graph paper.

Part 1 — Revisit the Challenge: 10 min

Display Pat's requirements on the board so students see them every day from here on:

- Game must use the catapult and a designed landing zone.
- About 40% of players should win a small prize. (Maximum, not exact.)
- About 10% of players should win a large prize. (Maximum, not exact.)
- Game should produce at least $50 per day in profit.

Part 2 — Test Launches (No Procedure Yet): 15 min

Tell groups: "Launch the catapult 10 times. Each time, mark where the projectile lands on the graph paper." Don't give them more detail than that. Walk around but resist the urge to fix things.

After 10 launches each, every group transfers their data points onto the class chart paper (one color per group).

Part 3 — Discussion & Building a Procedure: 20 min

Pull the class together in front of the chart. The points will look scattered and group-specific. That's the point — and the springboard for the discussion.

DISCUSSION PROMPTS — WHY IS THE DATA SO SCATTERED?

- Why does the data look so different between groups?
- How did your group decide where to put the clay on the scoop? Did you do it the same way every time?
- How far back did you pull the arm? Did everyone in your group pull it the same amount?
- Did you measure from the front of the clay, the back, or the middle?
- If someone tried to repeat your experiment using your data, would they get the same results?

As a class, establish a common launching procedure. Write it on chart paper that stays posted for the rest of the unit. A typical class procedure includes:

- Use the same catapult each time (groups don't swap).
- Pull the arm back the same amount — all the way to the frame, every time.
- Place the clay in the same spot on the scoop (e.g., center).
- Use the same size/weight clay ball each launch (e.g., 3 grams).
- Record landing position as the spot where the ball first lands — measure to the center of the ball.
- Catapult position is taped down — don't move it between launches.

TEACHER TIP — WRITE THE PROCEDURE WITH THEM

Resist the urge to hand students a finished procedure. Ask "What is one thing we need to do the same every time?" and let the class build the list. This is where students experience why scientists obsess over procedure — and they'll defend it later when other groups' procedures don't match theirs.

ACTIVITY 4

Launch Activity 2: Data Collection

Essential Question: How does a consistent procedure change what the data looks like?

TIME
~50 min

Using the common procedure from Activity 3, students conduct a second round of launches and collect data that will be the foundation for their landing zone design. They will see directly how much more consistent the data is when everyone follows the same steps.

SETUP & MATERIALS

- Have the class procedure poster from Activity 3 visible on the wall.
- Print one Launch Data Recording Sheet per group
- Catapults set up at the same positions used in Activity 3.
- Fresh class chart paper for the new data, labeled “Trial 2 — With Procedure.”

Part 1 — Review the Procedure: 10 min

Walk through the class procedure from Activity 3 with the whole class. Add or revise any steps that need clarification.

Introduce the Launch Data Recording Sheet. Each row records: launch number, projectile mass, landing position (x, y in cm or grid units), and observations. Emphasize units.

Part 2 — Data Collection: 30 min

Groups follow the class procedure to launch 10 times each, plotting landing positions on their group graph paper and recording each row on the Data Sheet. Every group member should take a turn launching.

When done, each group transfers their data points to the new class chart (one color per group again).

Part 3 — Compare the Charts: 10 min

Display the Trial 1 chart (no procedure) and the Trial 2 chart (with procedure) side by side.

DISCUSSION PROMPTS — WHAT CHANGED?

- How does Trial 2 look different from Trial 1?
- What does this tell us about the value of following a procedure?
- Even with the procedure, the data still isn’t perfectly identical. What might still be causing variability? (Possible answers: tiny differences in clay shape; the catapult arm wears slightly with use; the rubber band stretches a little each time.)
- If Pat’s real arcade game has the catapult played 100+ times per day, what does Trial 2 tell us about where most clay balls will land?

ACTIVITY 5

Target / Landing Zone Design

Essential Question: How do we use data to design a landing zone that meets the win-percentage targets?

TIME
~50 min

Using the data from Activity 4, students design a landing zone for Storm-the-Castle with two scoring regions — a Large Prize zone and a Small Prize zone — placed so the win percentages match Pat's requirements. Designs are sketched on graph paper that overlays the launch data.

SETUP & MATERIALS

- Each group needs their completed Launch Data Recording Sheet and graph paper plot from Activity 4.
- Print one Landing Zone Design Sheet per group (graph paper with the catapult position marked at the origin)
- Have colored pencils for shading the two prize zones.

Part 1 — Vocabulary & Targets: 10 min

Quick vocabulary build at the board:

- Precision: how tightly clustered your data points are. Cluster = high precision.
- Tolerance: the acceptable range for a measurement or zone.
- Uncertainty: even with a good procedure, no test is perfect. We can't predict any single launch — only the pattern.

Re-display Pat's requirements:

- ≤ 40% of launches land in the Small Prize zone (winning a small prize).
- ≤ 10% of launches land in the Large Prize zone (winning a large prize).

Walk through the design logic: students should size and place the zones so that roughly 4 out of every 10 launches land in the Small Prize zone and only 1 out of every 10 in the Large Prize zone. The Large Prize zone should be smaller and placed where the data is sparse; the Small Prize zone should be larger and placed where the data is denser.

Part 2 — Design Sketching: 25 min

In their groups, students sketch their landing zone on the Landing Zone Design Sheet (see Appendix E). The sheet shows the same coordinate grid they used in Activity 4 with the catapult position at the origin. Working together, groups:

1. Plot or trace their Activity 4 data points on the design sheet so they can see where launches actually landed.
2. Sketch a Large Prize zone (smaller, harder to hit) around an area where only about 1 out of 10 data points landed.
3. Sketch a Small Prize zone (larger, easier to hit) around an area where about 4 out of 10 data points landed.
4. Anywhere with no zone is a "No Prize" area.
5. Add a quick theme to the design (e.g., the castle gates, the moat, the dragon's mouth). The game still needs to feel like Storm-the-Castle.

Part 3 — Quick Check & Calculations: 15 min

Have groups count: of the 10 data points from Trial 2, how many fell in their Small Prize zone? In their Large Prize zone? Calculate the percentages. Do they meet Pat's requirements?

This is a first-draft calculation based on only 10 launches — students will validate with much more data in Activity 6.

DISCUSSION PROMPTS

- Why did we put the Large Prize zone where the data is sparse?
- If we make the zones too big, what happens to Pat's profit?
- If we make the zones too small, what happens to the game's fun?
- Two groups share their designs — what is similar? What is different?

ACTIVITY 6

Validation Testing

Essential Question: How do we know our design actually meets Pat's requirements?

TIME
~50 min

Students validate their first-draft landing zone by running 25 additional launches using the class procedure and recalculating win percentages with the larger data set. If the percentages drift outside Pat's requirements, groups revise their zones and retest.

SETUP & MATERIALS

- Each group needs their catapult, Landing Zone Design Sheet from Activity 5, and a Validation Launch Data Recording Sheet for the 25 validation launches, and a Validation Equations Sheet.
- Have erasable colored pencils ready so groups can revise their zones without starting over.
- ROTATION NOTE: Groups can take turns launching (15 min per wave) while the other wave updates calculations and prepares for the next round.

Part 1 — Why Validate?: 10 min

DISCUSSION PROMPTS — VALIDATION

- Our design was based on 10 launches. If Pat's arcade actually has the game played 100 times a day, would our 10-launch design predict things accurately?
- Think about flipping a coin. If you flip it 10 times, you might get 7 heads and 3 tails. If you flip it 1,000 times, what do you expect? Why is more data better?
- What does it mean to validate something? (Make sure it actually does what we said it would.)

Part 2 — Validation Launches: 30 min

Using the same class procedure, each group launches 25 times and records the landing position of every launch on the Validation Data Sheet. Groups overlay these new data points on their Landing Zone Design Sheet (using a different color from the Activity 4 data).

After all 25 launches, each group calculates:

- Small Prize win percentage = (landings in Small Prize zone ÷ 25) × 100%
- Large Prize win percentage = (landings in Large Prize zone ÷ 25) × 100%

Part 3 — Revise If Needed: 10 min

Groups compare their validation percentages to Pat's requirements (≤40% small, ≤10% large).

- If the design meets both requirements: great. The design is validated.
- If the Large Prize zone is winning too often: shrink it or move it to a sparser area.
- If the Small Prize zone is winning too rarely: enlarge it slightly or move it toward the data cluster.
- If the percentages are way off: it's likely the original 10-launch design was lucky. The 25-launch data is the truth.

Document any revisions on the Landing Zone Design Sheet — Pat (and the gallery walk audience) will want to see the iteration.

> **TEACHER TIP — TIME PERMITTING SECOND VALIDATION**
>
> If a group revises their design substantially, ideally they would run another 25 validation launches with the revision. If time permits this in a single class period, terrific — otherwise, accept the validation data as collected and document the design change in the next round.

ACTIVITY 7

Prizes and Profit

Essential Question: Can we make Storm-the-Castle profitable for Pat?

TIME
~50 min

Students use the validated win percentages from Activity 6 to pick prizes from a constrained menu, then calculate the daily profit for the redesigned Storm-the-Castle. The goal is to hit Pat's $50/day profit requirement. This activity reuses the revenue/cost/profit vocabulary from the Data Challenge — students should move quickly through the calculations.

SETUP & MATERIALS

- Print one Arcade Prize Menu and Calculation Sheet handout per group.
- Have calculators or pre-built spreadsheets ready.

Part 1 — Quick Recap: 5 min

Quick recap of vocabulary from the Data Challenge:

- Revenue = price per play × plays per day
- Cost per play = prize cost per play + operating cost per play
- Daily profit = (revenue per day) − (cost per day)

New numbers for Storm-the-Castle specifically:

- Price per play: $1.50 (unchanged from before)
- Operating cost per play: $0.20 (unchanged from before)
- Plays per day target: Pat estimates that a redesigned, more fun version of Storm-the-Castle could see plays double from 15/day to 30+/day. Use 30 plays/day for the calculation.

Part 2 — Pick Prizes from the Menu: 15 min

Hand out the Prize Menu. The menu gives students a list of prize options — three Small Prize choices at different cost points and three Large Prize choices at different cost points. Each group picks one Small Prize and one Large Prize.

Part 3 — Calculate Profit: 25–30 min

Using the validated win percentages from Activity 6 and the prize costs from the menu, groups complete the Storm-the-Castle Profit Calculation Sheet.

Worked example:

- Validation showed 40% small-prize wins, 10% large-prize wins, 50% no prize.
- Small Prize choice: $0.50 piece of candy → 40% × $0.50 = $0.20 prize cost per play (small)
- Large Prize choice: $2.50 plush dragon → 10% × $2.50 = $0.25 prize cost per play (large)
- Total prize cost per play: $0.20 + $0.25 = $0.45
- Operating cost per play: $0.20
- Total cost per play: $0.45 + $0.20 = $0.65
- Revenue per play: $1.50
- Profit per play: $1.50 − $0.65 = $0.85
- Daily profit: 30 × $0.85 = $25.50 — does NOT meet Pat's $50/day requirement.

If the design does not hit $50/day, groups must adjust. They can:

- Pick cheaper prizes from the menu (without making them boring)
- Tighten the Large Prize win percentage further (revisit the Landing Zone Design Sheet)
- Argue (with evidence) that the redesigned game would attract even more plays per day

DISCUSSION PROMPTS

- Which adjustment did your group choose? Why?
- What is the smallest change that gets you to $50/day profit?
- If you were a kid playing this game, would the prizes feel exciting enough? How do you balance that with profit?

ACTIVITY 8

Poster Creation

Essential Question: How do we communicate a data-backed design clearly on a single page?

TIME
~ 90 min

Each group creates a single-page poster that summarizes their redesigned Storm-the-Castle game board. The poster serves two purposes: it is the artifact Pat will see, and it is the centerpiece of the gallery walk in Activity 9. The poster template is scaffolded so all groups produce a comparable artifact within a single class period.

SETUP & MATERIALS

- Print a One-Page Poster Template per group on 11×17 or 24×18 paper. Alternatively, project the template and students can recreate format on poster board.
- Have markers, colored pencils, and tape ready for any photos or sketches groups want to attach.
- Have groups gather all their completed materials: Landing Zone Design Sheet, validation data, profit calculations, and force diagram.

Part 1 — Walk Through the Poster Template: 10 min

Project the One-Page Poster template and walk through each section. Emphasize that every claim in the poster must be supported with evidence. The template has six sections:

Game Name & Theme — Storm-the-Castle with the team's twist (e.g., Storm-the-Castle: Dragon's Lair).

1. Problem: what Pat asked for, in the team's words.
2. Design: a clean sketch of the landing zone with the Large Prize zone and Small Prize zone shaded and labeled.
3. Validation Data: the win percentages from Activity 6, plus a one-sentence note on whether the design was revised.
4. Profit Math: the daily profit calculation, with prize choices and final daily profit number.
5. Why It Will Work: 2–3 sentence pitch: why this design will save Storm-the-Castle for Pat.

Part 2 — Build the Poster: 60 min

Groups divide the work and complete the poster. Circulate and prompt:

- Does your sketch match your validated landing zone, not the first-draft one?
- Did you include the actual win percentages, not just words like "lots"?
- Is your daily profit number clearly visible on the poster?
- Could a kid in another class read this poster and understand the game?

Part 3 — Final Polish: 20 min

- Confirm that groups have titled their poster and added group members' names.
- Make any other finishing touches.
- Practice: Each group member practices answering a questions posed by the others.
- Place the poster face-down on their table, ready for the gallery walk in Activity 9.

ACTIVITY 9

Gallery Walk & Cliffhanger

Essential Question: What can we learn from each other's designs?

TIME
~50 min

Groups display their posters around the room. Students walk through, study each design, and leave structured feedback using Gallery Walk Feedback Slips. The unit closes with a class discussion ("Which designs would Pat actually buy?") and a cliffhanger that sets up the Design Challenge: Pat is now ready to add a brand-new game to the arcade.

SETUP & MATERIALS

SETUP & MATERIALS

- Have groups tape their posters around the perimeter of the room. Leave at least 3 feet between posters so students can read them comfortably.
- Print Gallery Walk Feedback Slips — at least 4 per student
- Have one chair per group placed near (but not at) the poster — one group member at a time will sit and answer questions when their poster is being read.

Part 1 — Set the Rules: 5 min

Quick walkthrough of the gallery walk:

- Visit at least 4 posters (not your own).
- At each poster, fill out one Feedback Slip: one thing you like, one question you have, one suggestion.
- Drop the slip in the envelope or basket next to the poster when you're done.
- When YOUR poster is being read, one group member stays at the chair to answer questions from visitors. Rotate every 5 minutes.
- Keep it moving — no more than 4–5 minutes per poster.

Part 2 — Gallery Walk: 25 min

Run the gallery walk. Use a timer chime every 5 minutes to keep students rotating. Circulate to keep things on pace and to prompt students to give substantive feedback rather than just "cool!"

Part 3 — Class Discussion & Cliffhanger: 15 min

Bring the class back together. Have each group quickly share the single best piece of feedback they received.

DISCUSSION PROMPTS

- If Pat could only buy ONE redesign for Storm-the-Castle, which would you pick? Why?
- Were there any design ideas you saw that you wished you had thought of?
- What was harder than you expected — the design, the testing, the profit math, or something else?
- What would you change about Storm-the-Castle if you had two more weeks?

LOOKING AHEAD — THE DESIGN CHALLENGE

“You just saved Storm-the-Castle. Pat is so impressed that you now have free rein. Pat wants a brand-new arcade game — one that doesn’t exist yet — to add to the lineup. Same catapult, but everything else is up to you. In the next unit, your team will design that new game from scratch.”

Companion Handouts

Handout 1 — Pat's Follow-Up RFP Letter

FOLLOW-UP REQUEST FOR PROPOSALS — Pixel Palace Arcade

Dear Student Engineers,

Thanks for the recommendations you sent me last month — I've already started making some of the changes you suggested. But there's one game on your "Loser" list that I'm not ready to give up on: Storm-the-Castle.

I love that game. It's the only catapult-based game in the arcade, and when kids do play it, they have a great time. The problem is exactly what you said: the targets are too hard to hit, almost no one wins, and the prizes are expensive when someone does. I need to do something about it before the game costs me any more money.

I'm hiring you again, this time to redesign the landing zone for Storm-the-Castle. The catapult stays — that's what makes the game fun. What needs to change is the target board. I need a new landing zone that:

- *Lets about 40% of players win a small prize*
- *Lets about 10% of players win a large prize*
- *Makes me at least $50 per day in profit*

I've ordered the same kind of catapult for your classroom so you can test your designs the way the real game works. Test it, design a landing zone, prove with data that it meets my requirements, and tell me what prizes I should give out.

If you can save Storm-the-Castle, I might let you design a brand-new game next.

Thanks again,

Pat "Pac" Manning

Owner, Pixel Palace Arcade

Handout 2 — Odds of Winning Data Sheet

Name: _____ Date: _____

INSTRUCTIONS

- Rotate through the four sample-game stations with your group.
- At each station, play the game 5 times. Mark wins (W) and losses (L) below.
- After all stations, calculate the odds of winning for each game using the formula: (# of wins ÷ total plays) × 100%

Game	Plays (mark W or L)	# Wins	Total plays	Odds of winning
1. Ring Toss				%
2. Bean Bag Toss				%
3. Bounce Cup				%
4. Coin Slide				%

Reflection — answer in 1–2 sentences each:

Which game was the easiest to win? Why?

_____

_____

Pat wants 40% of players to win a small prize and only 10% to win a large prize. Were any of the games close to those numbers? Which ones?

_____

_____

Handout 3 — Catapult Force Diagram

Name: _____ Date: _____

INSTRUCTIONS

- STEP 1 — Label the following parts of the diagram: Frame, Arm, Twisted String, Trigger
- STEP 2 — Add force arrows for: (a) the pull-back force on the arm, (b) the tension stored in the twisted string, (c) the release direction when the arm snaps forward, (d) the projectile's trajectory.
- STEP 3 — Add energy captions. Next to each arrow, write one short sentence about what is happening
- STEP 4 — Mark Newton's 3rd Law. Put a STAR ★ on the diagram where there is an action and reaction.

WORD BANK

Twisted String

Trajectory

Pull back

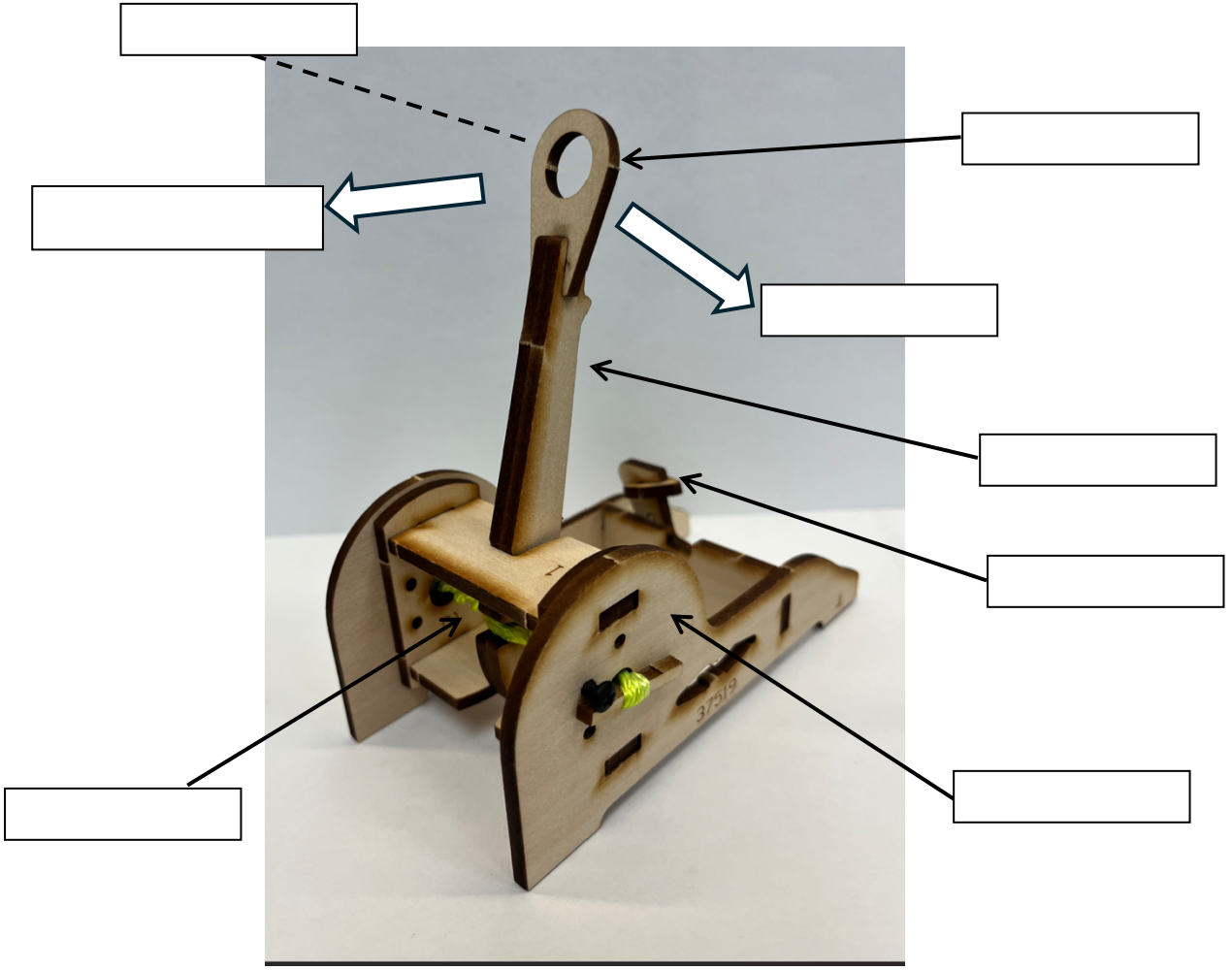
Forward motion

Arm

Scoop

Frame

Trigger



Handout 4 — Launch Data Recording Sheet

Name: _____ Date: _____

INSTRUCTIONS

- Record the landing position for 10 launches. Always use the same units (cm or grid squares).
- Note anything unusual in the Observations column.

What is your group trying to investigate?

_____

What data are you collecting?

_____

Launch Data — (10 launches)

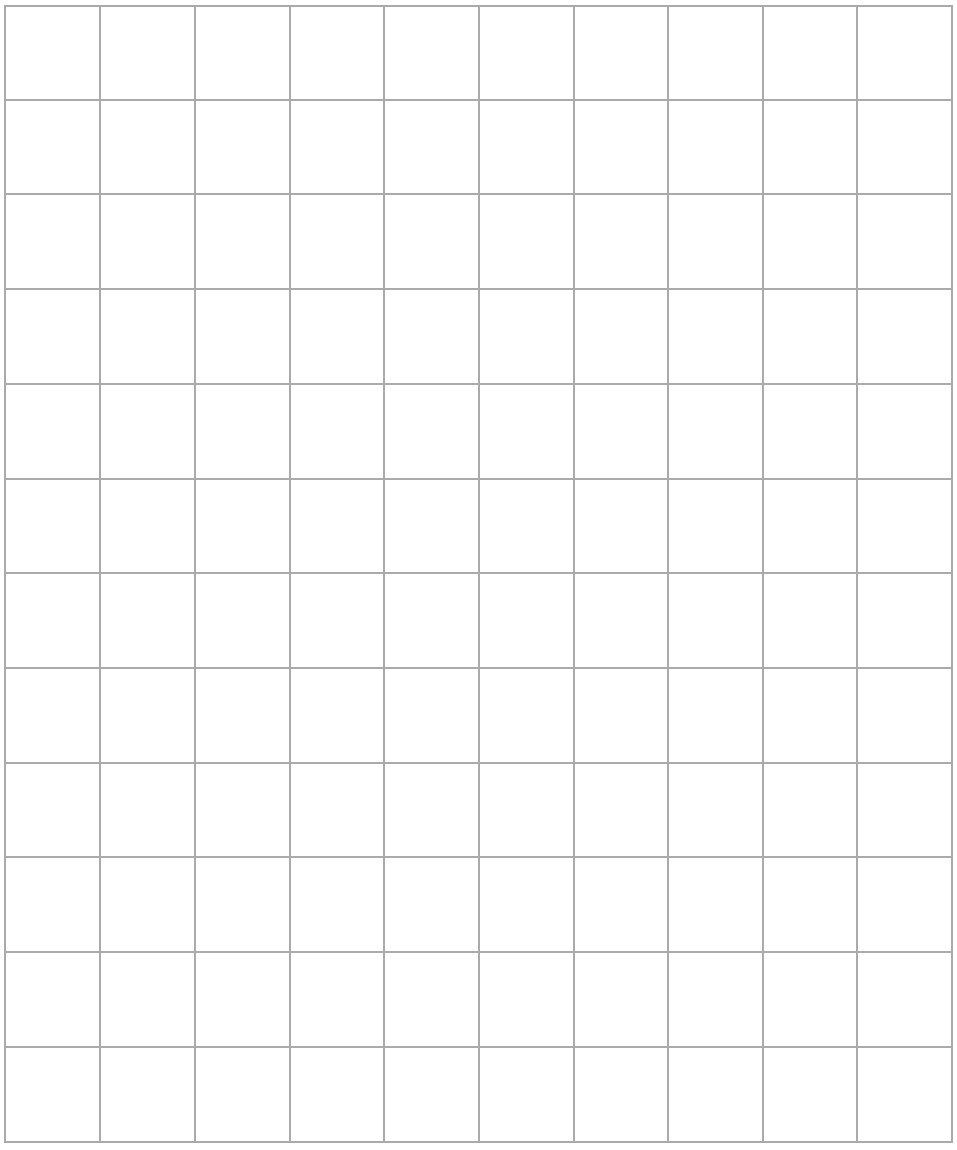
Launch #	Projectile mass (g)	Landing X	Landing Y	Observations
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Handout 5 — Landing Zone Design Sheet

Name: _____ Date: _____

INSTRUCTIONS

- Use this sheet to design and validate the landing zone for Storm-the-Castle.
- STEP 1 (Activity 3.3) — Plot your 10 launches from Activity 3.2 on the grid below. The catapult sits at the bottom center (origin).
- STEP 2 — Sketch a Large Prize zone (red) around a sparse area where about 1 out of 10 launches landed.
- STEP 3 — Sketch a Small Prize zone (yellow) around a denser area where about 4 out of 10 launches landed.
- STEP 4 (Activity 4.1) — Plot your 25 validation launches in a DIFFERENT color. Update your zones if needed.



▲ *Catapult sits at the bottom center* ▲

Game theme / name:

_____

Design notes (1–2 sentences on why you placed each zone where you did):

_____

_____

Revision notes (after validation):

_____

_____

Handout 6 — Validation Launch Data Recording Sheet

Name: _____ Date: _____

INSTRUCTIONS

- Record the landing position for 25 launches. Always use the same units (cm or grid squares).
- Note anything unusual in the Observations column.

Validation Launch Data — (25 launches)

Launch #	Projectile mass (g)	Landing X	Landing Y	Observations
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

Handout 7 - Validation Equations Sheet

Name: _____ Date: _____

INSTRUCTIONS

- After your 25 validation launches in Activity 4.1, fill in the equations below to calculate the actual win percentages for your landing zone design.
- Compare to Pat's requirements: ≤ 40% Small Prize, ≤ 10% Large Prize. If your design is outside these limits, revise.

Small Prize win percentage

Small Prize:		÷		×	100	=		%
	# landings in zone		*total launches*				*win %*	

Large Prize win percentage

Large Prize:		÷		×	100	=		%
	# landings in zone		*total launches*				*win %*	

Does your design meet Pat's requirements? ☐ Yes ☐ No

If NO, what will you change about your landing zone, and why?

_____

_____

_____

Revision documentation:

Describe the changes you made to your landing zone design and why you made them.

_____

_____

_____

Handout 8 — Arcade Prize Menu and Profit Calculation Sheet

Name: _____ Date: _____

INSTRUCTIONS

- Use your validated win percentages from Activity 4.1 to complete this sheet.
- STEP 1 — Pick one Small Prize and one Large Prize from the Prize Menu below.
- STEP 2 — Fill in the Profit Calculation table.
- STEP 3 — Check whether your design meets Pat's $50/day profit requirement. If not, revise (cheaper prizes, tighter Large Prize zone, etc.).

Prize Menu

Tier	Option	Cost	Notes
Small Prize A	Roll of arcade tickets (10)	$0.40	Boring but cheap
Small Prize B	Piece of candy	$0.50	Universally popular
Small Prize C	Sticker pack	$0.75	More exciting
Large Prize A	Small bouncy ball	$1.50	Cheapest "big prize" feel
Large Prize B	Plush dragon (mini)	$2.50	Ties to castle theme
Large Prize C	LED keychain	$3.50	Most exciting, most expensive

Our Prize Choices

Small Prize choice	Tier (A/B/C): _____	Cost: $ _____
Large Prize choice	Tier (A/B/C): _____	Cost: $ _____

Storm-the-Castle Profit Calculation

Validated win percentages (From Activity 6)	
Small Prize win %	_____ %
Large Prize win %	_____ %
Cost per play	
Small Prize expected cost per play = small % × small prize cost	$ _____
Large Prize expected cost per play = large % × large prize cost	$ _____
Operating cost per play (given)	$0.20
Total cost per play (add the three rows above)	$ _____
Daily profit	
Price per play (given)	$1.50
Profit per play = price per play − total cost per play	$ _____
Plays per day (given target)	30
Daily profit = profit per play × plays per day	$ _____

Does this meet Pat's $50/day requirement? ☐ Yes ☐ No

If NO, what will you change?

_____

_____

Handout 9 — One-Page Poster Template

INSTRUCTIONS

- This is the layout for your final poster. When you build the poster, scale this layout up to 11×17 or 24×18 paper.
- All six sections must appear. Use color and clear handwriting. Imagine Pat will see this from across the room.

Team / Group: _____

Group members: _____

1. GAME NAME & THEME *Storm-the-Castle with your twist (e.g., Dragon's Lair).*	**2. PROBLEM** *What Pat asked for, in 2–3 sentences.*
3. DESIGN *A clean, colored sketch of the landing zone with the Large Prize and Small Prize zones labeled.*	**4. VALIDATION DATA** *Your win percentages from the 25-launch validation. One sentence on whether you revised your design.*
5. PROFIT MATH *Your prize choices and your final daily profit number ($X.XX per day).*	**6. WHY IT WILL WORK** *Your 2–3 sentence pitch to Pat: why this design saves Storm-the-Castle.*

Handout 10 — Gallery Walk Feedback Slips

INSTRUCTIONS

- During the gallery walk, fill out one slip per poster visited.
- Drop the completed slip in the basket next to the poster.

GALLERY WALK FEEDBACK

Poster team: _____ Your Name: _____

One thing I LIKE about this design:

One QUESTION I have for this team:

One SUGGESTION to improve this design:

GALLERY WALK FEEDBACK

Poster team: _____ Your Name: _____

One thing I LIKE about this design:

One QUESTION I have for this team:

One SUGGESTION to improve this design:

GALLERY WALK FEEDBACK

Poster team: _____ Your Name: _____

One thing I LIKE about this design:

One QUESTION I have for this team:

One SUGGESTION to improve this design:_____

GALLERY WALK FEEDBACK

Poster team: _____ Your Name: _____

One thing I LIKE about this design:

One QUESTION I have for this team:

One SUGGESTION to improve this design:

This STEM Innovation and Design module was produced by Georgia Institute of Technology's Center for Education Integrating Science, Mathematics, and Computing with support from National Science Foundation Award #2101441.