## 6.5 Da Vinci Bridge Explore, Design, and Build: From Models to a Real Self-Supporting Bridge

In this all-day STEAM activity, 4th graders will step into Leonardo da Vinci's shoes and solve a classic engineering challenge: build a bridge without glue, nails or rope. The journey takes students through 6 exciting stages, where they go from studying historical sketches and the physics of friction to building their own functional model. Teams will work through a design thinking engineering cycle - research, conceptual design, modelling, prototyping in pencil and load testing their designs - to see how much weight their structure can support. In this challenge, students work in teams and have specific roles, where the designer leads the design, the builder assembles the structure, the tester measures the load capacity, the documenter documents the data, and the safety manager ensures that all materials are used responsibly. In a unique "knowledge exchange", the original teams are reorganised into new teams, encouraging students to share their experiences of success and failure with their peers, and the new teams use this information to build a second improved version of their prototype. The adventure culminates outdoors, where the students build a large wooden bridge based on the prototype models, with one and/or more teams.

## Basic Information Sheet

| Age group | Student number | Duration | Number of stages | Subjects connection and relevance |
|---|---|---|---|---|
| 4th grade students | Whole class (approx. 20–28 students), teams of 4–5 | 6 x 45 minutes | 6 stages | Science, Technology, Engineering, Arts, Mathematics |

### STEAM Event Summary

In this full-day STEAM program, teachers guide Grade 4 students through an authentic engineering challenge inspired by Leonardo da Vinci. Students begin by exploring da Vinci as an inventor and artist, then move into a structured engineering process:
problem definition → planning → prototyping → testing → redesign → real-world outdoor build.
They construct a tabletop bridge model (e.g., pencils/rods), test load capacity, analyse what makes structures stable, and finally build a larger outdoor version using wooden pieces (where conditions allow). The STEAM-day emphasizes engineering design thinking (iterate, test, improve), scientific reasoning (forces, friction, balance, stability), mathematical measurement (length, symmetry, simple load comparisons), creative communication (sketches, posters, presentations), collaboration and resilience (team roles, learning from failure).

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### SPIRIT Skill Focus

- Creativity
- Curiosity, sense of wonder and openness
- Valuing people and nature
- Resilience
- Connectedness
- Critical thinking
- Problem-solving

### National curriculum Link and Objectives

- Science: Understand basic principles of forces and stability (balance, friction, tension/compression in simple terms). Make predictions and test hypotheses through experimentation
- Technology and Engineering: Use materials intentionally; plan, build, test, improve a functional model. Apply the engineering cycle (define → design → build → test → improve).
- Mathematics: Measure and compare lengths; recognize symmetry and patterns. Estimate and compare loads/weights during testing.
- Arts / Literacy / History integration: Interpret da Vinci sketches; create design drawings. Communicate process through posters, diagrams, and short presentations.

## Real-world STEAM Connection and Problem definition

Imagine your team is exploring nature and you reach a stream or gap. There is no bridge, and it is not safe to cross. You cannot use glue, nails, or tape only the materials you can carry. Challenge question: How can we build a bridge that holds itself together using only smart structure and careful design? Leonardo da Vinci designed a bridge based on a clever interlocking pattern. Today, students will act as engineers: they will plan, prototype, test, and improve, then try a larger outdoor build to see how design choices work in real conditions.

## Materials at a Glance

Indoor Prototyping Materials (per team)

- 9–12 unsharpened pencils or wooden rods/dowels (same size works best)
- Optional stabilization elements for extensions only (rubber bands, clips) used after the “pure structure” attempt

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- Printed bridge images/sketches (da Vinci draft + real bridge photos)
- Rulers / measuring tape
- Planning sheets (bridge sketch + materials list + predicted load)
- Observation sheet (attempt 1 / attempt 2 comparison)

Testing Materials (indoor)

- Standardized test weights: small books, water bottles, identical blocks/containers
- Timer (optional), simple scorecard for load/time

Outdoor Build Materials (class set)

- Wooden slats/long sticks (pre-checked, no splinters)
- Work gloves (recommended)
- Cones/rope to mark safe boundary
- First-aid kit on site
- Clipboards / camera for documentation

Teacher / Classroom Setup

- Projector/slides for da Vinci intro (optional)
- Stations / trays for materials
- Labels for team roles (Engineer, Builder, Tester, Recorder, Safety Lead).

## Indoor/Outdoor and Classroom layout

Phase A – Indoor (Classroom / Makerspace):

- Research and inspiration: Exploring Leonardo da Vinci's ideas, historical bridges, and the core engineering problem through discussion, images, and short videos.
- Concept building and initial design: Identifying key principles of self-supporting structures and planning first solutions in teams
- Tabletop prototyping (Round 1): Building small-scale models using pencils/rods
- Testing, observation and reflection: Evaluating stability, identifying problems, and documenting findings

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- Peer regrouping and knowledge exchange: Teams are intentionally reshuffled after the first prototype, so students share insights, explain solutions, and learn from each other (connectedness, peer learning)
- Tabletop prototyping (Round 2): Applying newly acquired ideas to improved designs
- Documentation and reflection: Recording design decisions, challenges, and learning outcomes

Phase B – Outdoor (Schoolyard / Park area, if available):

- Real-world context (gap/stream simulation)
- Large-scale build using wooden pieces
- Outdoor testing, observation, photo documentation
- Safety-first procedures and clear boundaries
- This layout mirrors the template logic: introduction → making → testing → reflection, expanded into a full-day arc).

## Notes on Research-based approach and integration

This STEAM-day is built on inquiry-based learning and engineering design. Students do not receive a single "correct" method immediately; instead they are guided to explore, notice patterns, test ideas, and improve solutions. The teacher acts as a facilitator using structured questions rather than direct fixing. STEAM integration is explicit: science (forces, stability, friction, load testing), technology (using tools safely; documenting results: timer/camera optional), engineering (design cycle; constraints; prototyping; redesign), arts (da Vinci-inspired sketching, visual presentation), mathematics (measuring, comparing, recording, simple data tables; working with scale, ratios, and proportional reasoning when translating tabletop models into a larger real-world structure.

## Lesson Flow Overview (linked to details below)

| Stage | Title | Brief Description | SPIRIT Skills | Duration | Link to Details |
|---|---|---|---|---|---|
| 1st | **Spark and Context** | Students are introduced to STEAM-day through playful curiosity-building activities. They explore everyday objects by guessing their possible functions, then discover Leonardo da Vinci as an inventor, engineer, and artist. Through visual examples and storytelling, the bridge challenge is presented as a real-world problem. This stage builds motivation, activates prior knowledge, and frames the day's central engineering task. | • Curiosity, sense of wonder and openness<br>• Creativity | 45 minutes | **STAGE 1 – Spark and Context** |

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| **2nd** | **Science of Stability** | Through short, hands-on mini-investigations and guided observation, students explore key scientific concepts related to structures: balance, friction, load, and stability. They repeatedly watch and analyse short reference videos of self-supporting bridges, collecting observations and informal data about how elements interact, where forces act, and what contributes to stability. Using simple materials, students test what causes objects to tip, slide, or collapse, and compare their findings with what they observed in the videos. Based on this evidence, they synthesize insights and develop their own design ideas, rather than copying a single solution. This stage develops a shared scientific vocabulary and a research-based conceptual foundation for later bridge design. | • Critical thinking | 45 minutes | **STAGE 2 – Science of Stability** |
| **3rd** | **Plan Like an Engineer** | Working in teams, students take on defined engineering roles and analyse the design constraints of the bridge challenge (no glue, self-supporting structure, limited materials). They create planning sketches, discuss possible solutions, and predict which designs might work best. Emphasis is placed on teamwork, decision-making, and justifying ideas before building begins. | • Problem-solving | 45 minutes | **STAGE 3 – Plan Like an Engineer** |
| **4th** | **Build Prototype** | Teams build their first indoor bridge prototype using simple materials, focusing on structure rather than fixings. Students test ideas in practice, observe where designs fail, and adjust their approach. The teacher supports learning through guiding questions rather than direct solutions. This stage highlights experimentation, creativity, and learning through trial and error. | • Resilience<br>• Creativity | 45 minutes | **STAGE 4 – Build Prototype v1** |
| **5th** | **Test, Improve, and Knowledge Exchange** | Students systematically test their bridge prototypes by adding load and observing performance. Based on test results, they redesign and improve their structures, creating a second version. After the first testing round, teams are intentionally reorganized. Students explain their designs, testing outcomes, and improvements to new | • Critical thinking<br>• Flexibility | 45 minutes | **STAGE 5 – Test, Improve, and Knowledge Exchange** |

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| | | teammates, allowing ideas and strategies to circulate across the group. This peer exchange strengthens evidence-based reasoning, communication skills, and flexible problem-solving. | | | |
| **6th** | **Outdoor Build and Showcase** | Students transfer their indoor learning to a real-world context by building a larger bridge outdoors using wooden elements. They adapt designs to new conditions such as uneven ground and scale. The STEAM-day concludes with a reflection gallery, where teams showcase their work, discuss challenges and successes, and reflect on collaboration, engineering thinking, and the connection between design and nature. | • Connectedness<br>• Valuing nature and people | 45 minutes | **STAGE 6 – Outdoor Build and Showcase** |

## Tips and Tricks for dealing with challenges (for the whole STEAM program)

- Focus on process, not perfection: Emphasize planning, testing, and redesign rather than the final product.
- Treat failure as learning: Frame collapses or weak structures as valuable information for improvement.
- Use guiding questions instead of solutions: Support thinking with prompts (e.g., “What could you change first?”).
- Manage time visually: Display the STEAM-day stages so students see the learning journey.
- Define and rotate team roles: Clear roles ensure balanced participation and reduce conflict.
- Prepare extra materials: Expect breakage and redesign; spares keep momentum.
- Ensure safety indoors and outdoors: Set clear boundaries, use a stop signal, and supervise tool handling.
- Differentiate through challenge level: Allow teams to focus on stability, load, or redesign based on readiness.
- Value teamwork and creativity: Recognize collaboration, persistence, and innovative thinking.
- Close with reflection: End the day with sharing, a gallery walks, or short group reflections to consolidate learning.

## Difficulty level tailoring notes

Throughout the STEAM-day, differentiation is embedded in the learning process so that all students can participate meaningfully, regardless of prior experience or confidence level. Rather than separating learners by ability, the activity offers flexible entry points and varying depths of engagement, allowing students to progress at their own pace within mixed-ability teams. Students may move between levels depending on the task, their role within the group, or their growing confidence.

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- **Beginner learners:** Students receive structured support to understand the core idea of stability and self-supporting structures. Visual cues and simplified planning aids guide their thinking. Roles such as observer, recorder, or safety lead allow meaningful participation without the pressure of leading construction. The focus is on exploring one clear improvement at a time, supporting success through small, manageable design changes.
- **Advanced learners:** Students take an active role in building and redesigning the bridge. They typically create an initial prototype and a revised version, using observations and simple measurements to explain why certain elements worked or failed. Learners articulate cause–effect relationships in their own words and make collaborative decisions based on evidence gathered during testing.
- **Expert learners:** Students engage in deeper exploration by proposing alternative design variations and testing changes systematically, keeping some variables constant while modifying others. They compare results, identify patterns, and connect their designs to real-world bridges or historical structures inspired by Leonardo da Vinci. During the outdoor build, they also consider scale and environmental conditions, demonstrating the ability to transfer learning from classroom models to real-life contexts.

Across all levels, participation is equally valued. The emphasis remains on thoughtful engagement, collaboration, and learning through experimentation rather than on achieving a single “advanced” outcome.

## STEAM Program Debriefing and Reflection Questions

- What was your first idea about the bridge, and how did it change during the day?
- What helped your bridge stand without glue or nails?
- What was the biggest challenge, and how did your team try to solve it?
- What did you learn about balance, weight, or stability?
- How did your team work together, and what was your role?
- What are you most proud of from today’s work?
- Where could a bridge like this be useful in real life?
- If you had more time, what would you improve next?

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## 6.5.2. Stage details and Activities Flow

## STAGE 1 – SPARK AND CONTEXT

### How does this develop particular SPIRIT skills

This opening stage primarily develops curiosity, creativity, and openness, while also laying the foundations for critical thinking and connectedness. Through playful exploration and discussion, students are encouraged to look at familiar objects in unfamiliar ways, which supports flexible thinking and imagination. By listening to peers' ideas and responding respectfully, students practice openness to different perspectives and learn that there can be multiple possible solutions to the same problem. The introduction of Leonardo da Vinci as both an artist and an inventor helps students see that creativity and problem-solving are closely connected, reinforcing a STEAM mindset from the very beginning of the day.

### What do we want to achieve regarding SPIRIT skill development (student understanding and/or behaviour)?

By the end of this stage, students are expected to confidently share ideas in a group setting and to generate more than one possible explanation or function for an unfamiliar object. They begin to understand that inventions are created to respond to human needs or challenges, rather than appearing by chance. Students also practice explaining their thinking using simple reasoning (for example, linking an idea to a visible clue such as shape or material). Behaviourally, the goal is to establish a classroom culture in which curiosity is valued, ideas are shared without fear of being "wrong," and respectful listening becomes the norm for the rest of the STEAM-day.

### Academic/Curriculum Objective connection

- From a language and literacy perspective, this stage supports oral communication, vocabulary development, and basic argumentation skills. Students practice forming complete sentences such as "I think this could be used for…, because…"and responding to others' ideas.
- From a history and arts perspective, students are introduced to Leonardo da Vinci as a historical figure who combined observation, artistic skill, and inventive thinking. They begin to understand drawing and sketching as tools for thinking and planning, not only as artistic expression.
- This stage also supports cross-curricular STEAM readiness, as it prepares students for later scientific observation and engineering design by emphasizing careful looking, questioning, and idea generation.

### Materials and tools needed for implementation

- Mystery Objects Box containing 6-8 common object or unusual objects that can be interpreted in multiple ways
- Visual materials introducing Leonardo da Vinci, such as a short slideshow or presentation, or printed images of selected inventions (e.g. bridge sketches, mechanical designs), and one or two artworks to highlight the artist–inventor connection
- Board, flipchart, or large paper for collecting key ideas, vocabulary, and emerging questions during discussion

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- Markers or chalk for recording student responses
- Sticky notes for students to add ideas or questions visually (optional)

## Preparation notes

- Select 6–8 safe, tactile, and visually interesting mystery objects that do not have one obvious single function
- Prepare the Mystery Objects Box in advance so objects can be revealed one by one
- Choose 4–6 Leonardo da Vinci invention visuals that clearly show structure, mechanism, or problem-solving intent
- Select 1–2 artworks by da Vinci to highlight the connection between art and invention
- Test the slideshow or printed visuals in advance to ensure visibility for all students
- Plan the flow and timing of the stage to keep a lively pace and avoid overly long discussions
- Prepare open-ended guiding questions that encourage reasoning rather than correct answers
- Decide how key ideas and vocabulary will be recorded (board, flipchart, or large paper)
- Arrange classroom seating (circle or semi-circle) to support visibility, interaction, and discussion

## Guided Questions

Observation and Curiosity (warm-up questions):

- What do you notice about this object?
- What clues do you see (shape, material, size)?
- What do you think this object might be used for?

Reasoning and Explanation:

- Why do you think someone would invent something like this?
- What problem could this object help to solve?
- How does its shape or material support your idea?

Inventor Thinking and Creativity

- Why do inventors draw or sketch their ideas?
- How might an inventor improve this object?
- What could this object be used for in a different situation?

Connection to the Bridge Challenge:

- Why do people need bridges?
- What problems do bridges help us solve?
- What do you think makes a bridge strong or useful?

## Stage Debriefing Questions (Optional)

- What did we learn today about how inventors think?
- What idea surprised you the most?
- Did you hear an idea that made you change your mind?
- What helped you come up with new ideas?
- How did listening to others help your thinking?

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### Tips and Tricks for dealing with stage challenges

- Keep the pace lively and limit discussion time per object to maintain engagement. Encourage both imaginative (“wild”) ideas and evidence-based ideas, clearly valuing each type.
- If a few students dominate the discussion, intentionally invite quieter students to share or allow them to point out visual clues instead of speaking. Reframe off-topic ideas by asking follow-up questions that reconnect them to observation or problem-solving.
- Avoid judging ideas as right or wrong; use neutral responses such as “That’s an interesting possibility” or “Tell us what made you think that.”
- Use the board or flipchart to visually organize ideas, helping students see patterns and connections.
- If students struggle to generate ideas, model one example aloud and then step back. Reinforce respectful listening and turn-taking to set expectations for collaboration throughout the STEAM-day.

## STAGE 2 – Science of Stability

### How does this develop particular SPIRIT skills

This stage primarily develops critical thinking, curiosity, and problem-solving, while also strengthening openness and resilience. Through hands-on mini-investigations, students observe cause–effect relationships and begin to reason about why structures behave the way they do. They learn to question first impressions, test ideas, and revise their thinking based on evidence. Working together during investigations also supports respectful collaboration and shared sense-making.

### What do we want to achieve regarding SPIRIT skill development (student understanding and/or behaviour)?

- Students recognize that stability depends on balance, contact points, friction, and load distribution.
- Students describe observations using simple scientific language (e.g. stable, unstable, heavier, slips, balanced).
- Students make predictions before testing and reflect on results after testing.
- Students demonstrate patience and persistence when outcomes differ from expectations.
- Students listen to others’ explanations and build on shared observations.

### Academic/Curriculum Objective connection

- Science: Understanding basic concepts of forces, balance, friction, and stability through observation and experimentation. Developing early scientific reasoning by predicting, testing, observing, and explaining outcomes.
- Mathematics: Comparing quantities (more/less, heavier/lighter). Recognizing simple patterns related to structure and support.
- Language and Literacy: Using descriptive and explanatory language to communicate observations and ideas.

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## Materials and tools needed for implementation

- Unsharpened pencils, wooden sticks, or rulers (for balance and structure tests)
- Small weights (erasers, blocks, identical small books, or containers)
- Different surfaces for friction tests (smooth table, paper, fabric, sandpaper)
- Rulers or measuring tape
- Simple investigation cards or visual instructions (optional)
- Board, flipchart, or large paper for collecting observations and key terms

## Preparation notes

- Prepare 2–3 simple mini-investigation setups in advance (balance, friction, load).
- Test each activity beforehand to ensure it works within a few minutes.
- Decide whether investigations will be done as whole-class demonstrations or small-group rotations.
- Prepare key vocabulary to introduce or collect during discussion (e.g. balance, stable, slip, weight).
- Ensure materials are safe and easy to handle for all students.

## Guided Questions

Prediction and Observation:

- What do you think will happen if we add weight here?
- Which structure do you think will stand longer? Why?
- What do you notice when it starts to fall or slide?

Reasoning and Explanation:

- Why do you think this structure is more stable than the other one?
- How does the surface change what happens?
- Where do you see balance or imbalance?

Connection to Bridge Building:

- How could this idea help us when we build our bridge?
- What should we remember when we want something to stay standing?

## Stage Debriefing Questions (Optional)

- What did we discover about what makes a structure stable?
- Which test surprised you the most?
- Did any prediction turn out differently than you expected?
- What idea do you think will be most important for building our bridge?

## Tips and Tricks for dealing with stage challenges

- If students rush to conclusions, slow down the process by asking them to describe what they see before explaining why. Use comparisons (this vs. that) to support clearer thinking.

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- If attention drops, turn an investigation into a quick challenge (e.g. "Can you make it stand longer?"). Reinforce that this stage is about exploring and understanding, not about being correct.
- Clearly connect discoveries back to the upcoming engineering task to maintain relevance and motivation.

## STAGE 3 – Plan Like an Engineer

### How does this develop particular SPIRIT skills

This stage strongly develops problem-solving, collaboration, critical thinking, and responsibility. Students learn to slow down before acting, analyse constraints, and make intentional decisions as a team. By discussing ideas, negotiating roles, and justifying design choices, they practice respectful communication and shared ownership of the task. Planning before building also supports resilience, as students understand that redesign is part of an expected process rather than a sign of failure.

### What do we want to achieve regarding SPIRIT skill development (student understanding and/or behaviour)?

- Students understand that engineering begins with planning, not immediate construction.
- Students identify and respect design constraints (self-supporting structure, no glue or nails, limited materials).
- Students generate and discuss multiple design ideas before selecting one.
- Students justify design choices using simple reasoning and evidence from Stage 2 discoveries.
- Students take responsibility for a specific role within their team and collaborate effectively.

### Academic/Curriculum Objective connection

- Technology and Engineering: Applying the engineering design process: define the problem, plan a solution, and prepare for testing. Understanding the role of constraints and criteria in engineering challenges.
- Mathematics: Measuring and estimating distances (bridge span, gap width). Comparing quantities (number of pieces used, planned height or width).
- Arts / Visual Literacy: Creating clear planning sketches and diagrams to communicate ideas visually.
- Language and Literacy: Using structured oral language to explain plans, roles, and decisions.

### Materials and tools needed for implementation

- Planning sheets with space for bridge sketch, list of materials, predicted strengths and weak points
- Unsharpened pencils, wooden rods, or sticks (for testing ideas while planning)
- Rulers or measuring tape
- Images of Leonardo da Vinci bridge sketches and real bridge examples (for inspiration)
- Role cards or labels (Engineer, Builder, Tester, Recorder, Safety Lead)
- Board or flipchart for recording shared constraints and success criteria.


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### Preparation notes

- Decide on the standard gap size that all teams will plan for.
- Prepare and copy planning sheets in advance.
- Create clear role descriptions so students understand expectations.
- Review Stage 2 findings and select 2–3 key ideas to remind students of (e.g. balance, contact points).
- Prepare example sketches only as inspiration, not as models to copy exactly.

### Guided Questions

- Understanding the Challenge: What exactly is our problem to solve today? What are the rules and limits we must follow
- Planning and Design: How will the pieces hold together without glue or tape? Where might the bridge be weakest? How can we use balance or shape to make it stronger?
- Teamwork and Roles: Who will focus on which task in your team? How will you make decisions if you disagree?
- Prediction: What do you think will work best in your design? Why?

### Stage Debriefing Questions (Optional)

- What was the most important decision your team made during planning?
- Did everyone have a role? How did that help?
- What part of your plan are you most confident about?
- What do you think might be challenging when you start building?

### Tips and Tricks for dealing with stage challenges

- If students want to start building immediately, remind them that engineers always plan first. Encourage teams to keep plans simple rather than complex.
- If disagreements arise, suggest testing ideas later instead of arguing now. Support students who struggle with drawing by allowing symbols or labels instead of detailed sketches.
- Reinforce that plans can change; planning is a guide, not a final answer.
- Keep time visible and give a 5-minute warning before moving to the next stage.

## STAGE 4 – Build Prototype

### How does this develop particular SPIRIT skills

- Develops resilience by allowing students to experience failure and learn from it.
- Strengthens creativity through hands-on experimentation with structure and form.
- Encourages problem-solving as students adapt plans when ideas do not work as expected.
- Supports collaboration and responsibility through role-based teamwork.
- Reinforces openness to change and flexibility in thinking.

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## What do we want to achieve regarding SPIRIT skill development (student understanding and/or behaviour)?

- Students translate a drawn plan into a physical structure.
- Students test ideas in practice and observe what works and what does not.
- Students remain engaged even when the structure collapses or fails.
- Students suggest at least one possible improvement based on observation.
- Students cooperate respectfully and follow agreed team roles.

## Academic/Curriculum Objective connection

- Technology and Engineering: Building a functional prototype under given constraints. Understanding that engineering solutions require testing and revision.
- Science: Observing stability, balance, and force effects during construction.
- Mathematics: Measuring span, height, or alignment during building.
- Language and Literacy: Using descriptive language to explain problems and ideas within the team.

## Materials and tools needed for implementation

- Unsharpened pencils, wooden rods, or dowels (one set per team)
- Planning sheets from Stage 3
- Rulers or measuring tape
- Flat working surface (table or floor space)
- Optional: camera or tablet for documenting attempts
- Board or flipchart for recording common challenges or discoveries

## Preparation notes

- Ensure all teams have equal quantities of materials.
- Prepare a standard testing gap (e.g. two chairs or marked floor space).
- Review safety rules for handling long objects.
- Decide in advance that no fixings (glue, tape, rubber bands) are allowed during this first build.
- Plan to circulate and observe rather than intervene directly.

## Guided Questions

Observation and Reflection:

- What is happening as you place this piece?
- Where does the structure start to wobble or collapse?

Problem-Solving:

- What could you change without starting over?
- How might adjusting the angle or position help?

Connection to Planning:

- How does this compare to your original plan?
- What part of the plan worked better than expected?

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### Stage Debriefing Questions (Optional)

- What was the biggest challenge during building?
- Did anything surprise you when you started constructing the bridge?
- What would you like to change in the next version?
- What did you learn from something that did not work?

### Tips and Tricks for dealing with stage challenges

- Remind students that collapse is part of the learning process, not a mistake.
- Encourage small adjustments instead of complete rebuilds when possible.
- If frustration rises, pause the group briefly and refocus on observation.
- Avoid giving direct solutions, guide students with questions instead.
- Highlight examples of persistence and teamwork during the activity.
- Give a clear time warning (e.g. “10 minutes left”) to support pacing.

## STAGE 5 – Test, Improve, Document

### How does this develop particular SPIRIT skills

- Develops critical thinking by encouraging evidence-based evaluation of designs.
- Strengthens flexibility as students modify ideas based on test results.
- Reinforces problem-solving through iterative redesign.
- Supports resilience by framing failure as useful feedback.
- Encourages communication and connectedness through sharing results and explanations.

### What do we want to achieve regarding SPIRIT skill development (student understanding and/or behaviour)?

- Students test their bridge prototype using a clear and fair method.
- Students observe and describe how the structure reacts to added load.
- Students identify at least one weakness in their first design.
- Students redesign and build an improved second version of the bridge.
- Students explain what they changed and why, using observations as evidence.
- Students document their process through sketches, notes, or simple data.

### Academic/Curriculum Objective connection

- Science: Observing cause–effect relationships between structure and load. Understanding stability through testing and comparison.
- Mathematics: Measuring span and counting or comparing weights added. Recording results in simple tables or diagrams.
- Technology and Engineering: Applying the engineering design cycle: test → analyse → improve.
- Language and Literacy: Using explanatory language to describe results and justify decisions.

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## Materials and tools needed for implementation

- Completed bridge prototypes from Stage 4
- Standardized test weights (small books, identical blocks, water bottles)
- Containers or markers to count added load
- Rulers or measuring tape
- Observation and redesign sheets
- Pencils or markers
- Board or flipchart for collecting class-wide observations

## Preparation notes

- Decide on a standard testing protocol for all teams (same gap, same type of weight).
- Prepare enough identical weights to ensure fairness.
- Review safety rules, emphasizing that weights, not students, test the bridge.
- Prepare documentation sheets with clear sections: test results, changes made, why it improved.
- Plan time for both testing and redesign within the 45-minute block.

## Guided Questions

Testing and Observation:

- What happens when we add weight here?
- Where does the bridge start to change or fail?

Analysis and Improvement:

- Why do you think it failed at this point?
- What is one small change that could make it stronger?
- How can we test whether that change really helps?

Documentation and Communication:

- How will you show what you changed?
- What evidence do you have that your design improved?

## Stage Debriefing Questions (Optional)

- What change made the biggest difference in your bridge?
- How did testing help you decide what to improve?
- Did your second version work better than the first? Why?
- What did you learn from another team's design?

## Tips and Tricks for dealing with stage challenges

- Emphasize slow, careful testing rather than rushing to add weight.
- If teams feel discouraged, highlight partial success (e.g. "It held one more block"). Encourage teams to change one variable at a time for clearer results.

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- Support students who struggle with writing by allowing diagrams or labelled sketches.
- Keep sharing brief and focused to leave time for redesign.
- Reinforce that improvement, not maximum load, is the key success indicator.

## STAGE 6 – Outdoor Build and Showcase

### How does this develop particular SPIRIT skills

- Develops connectedness by placing learning into a real-world, outdoor context.
- Strengthens valuing people and nature through responsible material use and safe cooperation outdoors.
- Reinforces collaboration as teams coordinate actions in a larger space with real constraints.
- Supports resilience and flexibility as students adapt indoor designs to outdoor conditions.
- Encourages reflection and self-awareness by looking back on the full STEAM-day journey.

### What do we want to achieve regarding SPIRIT skill development (student understanding and/or behaviour)?

- Students transfer design principles from indoor prototypes to a larger-scale outdoor structure.
- Students adapt plans in response to environmental factors such as uneven ground or wind.
- Students demonstrate safe and responsible tool and material handling.
- Students communicate effectively within their teams during construction.
- Students reflect on both the process and the outcome of their work.
- Students recognize their role in a collaborative engineering achievement.

### Academic/Curriculum Objective connection

- Technology and Engineering: Applying engineering design thinking in a real-world context. Understanding scale and material constraints in construction.
- Science: Observing how external factors affect stability and structure.
- Mathematics: Estimating distances and comparing sizes between indoor and outdoor builds.
- Arts and Communication: Presenting work visually and orally through a showcase or gallery.
- Environmental Awareness: Practicing responsible interaction with the outdoor environment.

### Materials and tools needed for implementation

- Wooden slats, long sticks, or pre-cut wooden elements (checked for safety)
- Work gloves (recommended)
- Cones, ropes, or markers to define safe working boundaries
- Clipboards, cameras, or tablets for documentation
- Reflection cards or sticky notes
- First-aid kit available on site

### Preparation notes

- Inspect the outdoor area in advance for safety and suitability.
- Decide on a clear build zone and observation zone.
- Prepare a contingency plan for bad weather (large indoor space or simplified build).


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- Review safety rules with students before starting outdoor construction.
- Prepare reflection prompts or display space for the showcase.

## Guided Questions

During Building:

- What is different about building outdoors compared to indoors?
- How does the ground or space affect your structure?

During Observation:

- Which parts of the bridge seem most stable?
- Where do you see challenges caused by scale or environment?

During Reflection:

- What helped your team work well together?
- How did today's testing help you think like an engineer?

## Stage Debriefing Questions (Optional)

- What was the biggest difference between your indoor and outdoor bridge?
- What did you have to change when you moved outside?
- What are you most proud of from today's STEAM-day?
- What did you learn about working as a team?

## Tips and Tricks for dealing with stage challenges

- Keep safety the top priority; pause construction if conditions become unsafe.
- Assign clear roles again to avoid crowding and confusion outdoors.
- If time is limited, focus on one successful outdoor build per team rather than perfection.
- Encourage observation and discussion even if the outdoor build is partial.
- Emphasize reflection and learning over final appearance or strength.
- Capture photos or short notes to help students remember and share their experience later.

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