

Cardboard Automata – *The Nightingale*

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1. Materials Checklist

- **Base Structural Materials:**
 - Recycled corrugated cardboard (for the outer box, movement wheels/cams, and the bird's body).
 - Disposable chopsticks or wooden skewers (to serve as the main rotation axles).
 - Paper clips (for creating linkages or providing fine-tuned structural support).
- **Artistic & Decorative Supplies:**
 - Colored cardstock, feathers, or lightweight fabric (to decorate the nightingale).
 - Paintbrushes, paints, or markers.
 - Reference images of nightingales and wing skeletal structures.
- **Tools & Adhesives:**
 - Hot glue gun and glue sticks (essential for bonding; requires adult supervision).
 - Strong liquid glue or transparent tape.
 - Utility knife and scissors.
 - Compass or various-sized bottle caps (to trace circular cams/wheels).

2. Preparation Guide

- **Material Performance Testing:** The thickness of the cardboard determines the stability of the mechanism. Before the lesson, instructors should guide students to test the power difference between a single-layer cardboard wheel and a multi-layered one (e.g., gluing four circles together to create a wider cam).
- **Kinematic Principles:** Pre-prepare a simple "Cam and Follower" model to demonstrate to students how "rotational motion" is converted into "vertical reciprocal motion."
- **Resource Gathering:** Collect anatomical diagrams of different bird wings. This helps students understand the relationship between shape and movement trajectory, preventing designs that are too complex to actually flap.

3. Teaching Plan

Phase	Activity	Learning Objective

Phase 1: Literary & Drama Intro	Recount Andersen's <i>The Nightingale</i> ; discuss the dialectic between "natural beauty" and "artificial ingenuity."	Establish emotional connection and understand the narrative context.
Phase 2: Design & Observation	Students observe bird wing structures through sketching; plan the mechanical box and axle positions.	Enhance observation skills and introduce basic mechanical drawing concepts.
Phase 3: Iteration & Engineering	Initial Attempt: Build basic lift; Iteration: Solve weight/power issues (e.g., widening the cam); Optimization: Find better materials (e.g., using chopsticks instead of fragile paper).	Practice the Engineering Design Process; understand "failure as a source of knowledge."
Phase 4: Performance & Reflection	Integrate the finished automata into a drama performance; reflect on the human creativity and craftsmanship within the object.	Synthesize arts and engineering; deepen the reflection on the relationship between nature and craft.

4. Teaching Case Study

Project Name: From "Failed Wings" to the "Flying Nightingale"

Background: A student attempting to recreate the mechanical bird from the story initially planned an extremely complex, multi-jointed folding wing system.

Implementation Process:

1. **The Frustration Phase:** In the first iteration, the student found that the complex cardboard joints were too heavy and lacked support, failing to move when driven by the wheel (as seen in the original Figure 2).
2. **The Turning Point:** The student discovered that using straightened paper clips and chopsticks provided more stability than cardboard alone. They pivoted from a "realistic"

multi-joint design to a more functional one, widening the drive wheel (stacking four layers of cardboard) to increase friction and force.

3. **Outcome & Reflection:** After three iterations, the nightingale achieved a smooth flapping motion. The student reflected: "At first, I only focused on my plan, but through the constant 'negotiation' with materials, I truly understood the mechanics. This bird is not just a tool; it embodies 10 hours of my focus and heart."



Core Educational Philosophy:

This plan emphasizes the integration of **"Hard and Soft Approaches"**. Educators should not simply provide a manual but allow students to "dialogue" with physical materials (cardboard, sticks) to discover problems, building their own knowledge base through constant **iteration**.