

## LESSON 10

## Building a Mechanical Crawler

"Mimicking Nature with Robotics" — Biomimicry &amp; Tiller Control

## LESSON OVERVIEW

<b>Subject Area</b>	STEAM, Computer Science
<b>Grade Level</b>	Grades 4–6 (Adaptable for Grades 7–8 with increased complexity)
<b>Duration</b>	3 Class Periods × 45–60 Minutes = 135–180 Minutes Total
<b>Framework</b>	5E Instructional Model (Engage → Explore → Explain → Elaborate → Evaluate)
<b>Key Themes</b>	Biomimicry • Caterpillar Locomotion • Tiller Control • Peristaltic Motion • MakeCode
<b>Materials</b>	NEZHA Inventor's Kit V2 • MakeCode • Whiteboard • Rulers/Measuring tapes • Optional: Craft materials

## LEARNING OBJECTIVES

- 01 Design and build a mechanical crawler using the NEZHA Inventor's Kit V2 that mimics caterpillar locomotion.
- 02 Explain the basic components and functions of the NEZHA Inventor's Kit V2 including the Nezh board and motors.
- 03 Use the tiller component to control the direction and range of the mechanical crawler's movement.
- 04 Explore the characteristics of caterpillar crawling: peristaltic wave motion, segment coordination, and grip.
- 05 Apply problem-solving skills to troubleshoot challenges during the building and programming process.

## KEY VOCABULARY

Term	Definition
<b>Biomimicry</b>	Design practice that takes inspiration from natural organisms and processes.
<b>Tiller</b>	Control component in the kit that adjusts the steering or direction of

	movement.
<b>Peristalsis</b>	Wave-like muscle contraction moving from back to front; used by caterpillars to crawl.
<b>Locomotion</b>	Ability of a robot or animal to move from place to place under its own power.
<b>Segment</b>	One section of a segmented body; caterpillars use sequential segment motion to crawl.
<b>Control System</b>	Hardware and software that directs a robot's behavior in response to inputs.
<b>Flowchart</b>	Visual diagram showing the sequence of steps and decisions in a process.
<b>Iteration</b>	Repeating the design-test-improve cycle to progressively improve robot performance.

5E MODEL — LESSON PLAN

ENGAGE

Step	Activity	Key Focus
1	Show students a 60-sec video of a caterpillar crawling in slow motion; pause and observe the wave.	Spark curiosity and provide detailed visual inspiration for the build.
2	Ask students to observe the caterpillar's movement: 'Which part moves first? Last? How does the wave travel?'	Develop observational and analytical science skills.
3	Introduce the challenge: 'Build a mechanical crawler that mimics caterpillar motion using NEZHA Kit V2!'	Provide a clear, biologically inspired, and achievable engineering goal.
4	Introduce the concept of biomimicry: engineers who study nature to solve design problems.	Connect robotics engineering to biology and real-world design philosophy.

EXPLORE

Step	Activity	Key Focus
1	Divide students into small groups; provide each group with a NEZHA Inventor's Kit V2.	Foster collaboration, distributed roles, and shared responsibility.
2	Have students explore the kit's components; identify and categorize: structural, motor, sensor, control.	Encourage systematic hands-on learning and component understanding.
3	Guide students to think about how the peristaltic wave can be modeled mechanically.	Develop engineering design thinking and biomimicry application skills.

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Encourage students to sketch 2 different design ideas and share them within the group.

Promote creativity, visual communication, and design iteration.

## □ EXPLAIN

Step	Activity	Key Focus
1	Facilitate class discussion: share design sketches and identify common challenges anticipated.	Encourage collaboration, shared problem-solving, and collective analysis.
2	Introduce the tiller component: demonstrate how adjusting the tiller changes direction and range.	Build understanding of mechanical control systems and tiller function.
3	Explain basic principles of programming the Nezha board using MakeCode: motor blocks, timing.	Integrate coding knowledge into the hands-on robotics project.
4	Provide students with a step-by-step flowchart to guide their programming sequence.	Offer structured support while maintaining student agency in coding.

## □ ELABORATE

Step	Activity	Key Focus
1	Have students work in groups to build and program their mechanical crawlers using their sketches.	Apply design, engineering, and coding skills in an integrated way.
2	Encourage students to test their crawlers: does the wave motion look like a caterpillar's?	Promote iterative design: test → observe → adjust tiller or timing → re-test.
3	Challenge students to add one creative feature: color decoration, a cargo platform, or extra segments.	Foster creativity and innovation beyond the core functional requirement.

## □ EVALUATE

Step	Activity	Key Focus
1	Each group presents their crawler: demonstrate movement, explain tiller function and biomimicry connection.	Assess creativity, design functionality, and communication skills.
2	Students reflect on design and build process: biggest challenge, how they overcame it, what they would change.	Develop critical thinking and self-reflection as engineers.
3	Rubric assessment: crawler functionality, biomimicry accuracy, creativity, and MakeCode logic.	Conduct summative assessment against established criteria.
4	Students complete self-reflection or peer evaluation on teamwork and individual contribution.	Evaluate collaborative skills and individual growth throughout the

project.

□ PERIOD-BY-PERIOD TEACHER & STUDENT SCRIPTS

PERIOD 1 — ENGAGE (40 min)

Time	Teacher Actions	Student Actions	Key Questions
0–8 min	Play slow-motion caterpillar video. Ask: 'Which body segment moves first? How does the wave travel?'	Sketch the caterpillar and draw arrows showing the direction of the wave motion.	How is a caterpillar's crawl different from a snake's motion?
8–20 min	Introduce biomimicry: show examples (Velcro from burrs, bullet train from kingfisher beak).	List 3 examples of biomimicry in everyday products from classroom discussion.	What animal motion would you most want to mimic in a robot? Why?
20–35 min	Groups explore kit: sort components into 4 categories (structural, motor, sensor, control).	Label component categories on a worksheet; identify 3 components that create motion.	How does the tiller component change what the robot does?
35–40 min	Groups sketch 2 crawler designs; choose one to build based on group vote.	Record chosen design in notebook with at least 4 labeled parts and biomimicry connection.	How does your chosen design mimic the caterpillar's peristaltic wave?

PERIOD 2 — EXPLORE (45 min)

Time	Teacher Actions	Student Actions	Key Questions
0–15 min	Coach build phase: check segment connections, tiller position, and motor mount security.	Assemble crawler body and attach tiller; verify all segments move when motor runs.	Does your crawler stay together when you run it? What needs reinforcing?
15–30 min	Guide MakeCode: motor forward (1.5s) → pause (0.5s) → tiller adjust → repeat.	Program basic crawl sequence; download and run. Observe whether wave motion appears.	Does your robot's movement look like a caterpillar's? What's different?
30–38 min	Tiller experiment: adjust tiller setting 3 times; measure turning radius for each.	Record tiller setting → turning radius in data table for all 3 positions.	What tiller setting gives the straightest path?
38–45 min	Creativity extension: add one decorative or functional feature to the crawler.	Add one modification (color, cargo platform, extra segment) and explain its purpose.	How does your added feature change the robot's functionality or appearance?

PERIOD 3 — EXPLAIN → ELABORATE → EVALUATE (45 min)

Time	Teacher Actions	Student Actions	Key Questions
0–15 min	Mini-lecture: peristaltic wave mechanics, segmented locomotion in nature vs. robotics.	Label the peristaltic wave on their crawler sketch; identify which component creates each phase.	How many motor cycles does it take for your robot to complete one full wave?
15–30 min	Gallery showcase preparation: 10 min to finalize crawler and practice 60-sec presentation.	Practice presenting: how it was built, how the tiller works, biomimicry connection.	How will you explain the connection between caterpillar motion and your crawler?
30–42 min	Each group demonstrates crawler to class and presents their biomimicry design rationale.	Demonstrate live; explain tiller function, MakeCode logic, and one design challenge overcome.	What real engineering application could use a similar crawling mechanism?
42–45 min	Exit ticket: sketch the peristaltic wave + label 3 programming parameters in the MakeCode.	Complete individually and submit before leaving.	How would you redesign your crawler to carry a small object from point A to B?

### DIFFERENTIATION & SCAFFOLDING

SUPPORT — Struggling Students	EXTENSION — Advanced Students
<ul style="list-style-type: none"> <li>• Provide a pre-assembled segment frame so students focus on tiller adjustment and programming.</li> <li>• Offer a MakeCode template with motor blocks pre-placed; students only set timing values.</li> <li>• Allow extra time for the build phase by starting segment assembly in Period 1.</li> <li>• Use the biomimicry worksheet to scaffold the caterpillar observation and design steps.</li> </ul>	<ul style="list-style-type: none"> <li>• Challenge students to build a crawler with 5+ segments that shows a visible peristaltic wave.</li> <li>• Incorporate a moisture or ultrasonic sensor to make the crawler react to its environment.</li> <li>• Compete in a class crawler showcase: judged on biomimicry accuracy, speed, and creativity.</li> <li>• Research how peristaltic robots are used in medicine (surgical bots) and write a one-page analysis.</li> </ul>

### ASSESSMENT BREAKDOWN

Assessment Component	Weight	Description
Exit Ticket	20%	Peristaltic wave sketch + 3 labeled MakeCode parameters (individual)
Crawler Functionality	25%	Robot crawls forward with visible wave motion for at least 50 cm
Biomimicry Analysis	20%	Written/verbal explanation connecting design to caterpillar locomotion
Group Presentation	20%	Live demo with clear explanation of tiller function and

		design process
Engineering Notebook	15%	Sketches, tiller data, iteration notes, and reflection entry

□ TEACHER NOTES

- Adapt lesson complexity based on student abilities and available time.
- Encourage collaboration and peer support throughout the design process.
- Emphasize the value of iterative design: every 'failure' is data for the next attempt.
- Celebrate creativity, originality, and engineering effort regardless of final outcome.
- Provide regular formative check-ins using the engineering notebook as a formative tool.

□ REAL-WORLD CONNECTIONS

**The engineering principles explored in this lesson appear throughout real-world industries:**

- Robotics Engineering: Professional robots use the same motor control and sensor concepts in manufacturing, medicine, and exploration.
- Biomimicry Design: Engineers worldwide study animals to design better robots, vehicles, and structures.
- STEAM Integration: The connection between art, science, math, and engineering is a cornerstone of 21st-century innovation.
- Career Connections: Robotics engineers, software developers, mechanical engineers, and product designers all apply these skills daily.