
SPACE SCIENCE KIT

Space Experiments — Lesson 08

Enhanced Lesson Plan | Grades 6–8 | Science, Technology, Engineering

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LESSON OVERVIEW

Lesson Title	Design, Build & Program: Space Experiment Apparatus — Scientific Investigation in Microgravity
Subject Area	Science, Technology, Engineering (STEM)
Grade Level	Grades 6–8 (Adaptable for 5 and 9)
Duration	3 Class Periods × 45 Minutes (135 minutes total)
Key Themes	Space Science Research, Microgravity Effects, Automated Data Collection, Controlled Experiments, Scientific Inquiry
Framework	5E Instructional Model (Engage, Explore, Explain, Elaborate, Evaluate)
Builds On	Lesson 07 — Space Station (confidence with event-driven forever loops, simultaneous operations, and orbital systems context)

LESSON CONTEXT

What makes Lesson 08 a new kind of challenge?

- In Lesson 07, students designed and operated a space station as infrastructure. In Lesson 08, they use that station as a platform for science — designing and building the actual experiment apparatus that runs inside it.
- The key new concept is the scientific method applied to engineering: each team chooses a type of space experiment (plant growth, material science, fluid dynamics, or human biology), designs an apparatus to simulate it, and programs automated data collection to run the experiment.
- The programming challenge builds directly on Lesson 07's forever loop: students now add timed data sampling (reading and recording the Sonar:bit value at set intervals to simulate experimental measurements), motor-controlled experiment cycles, and LED data logging codes.
- Lesson 08 introduces the concept of a control variable in engineering: real space experiments must identify what they are measuring (the variable) and what stays constant (the control). Students apply this to their model by defining their experiment's independent and dependent variables before they build.

EXPERIMENT TYPE MENU

Each team selects one experiment type from the menu below at the start of Day 1. All types use the same hardware (motor + Sonar:bit) but model different scientific investigations. This choice-based structure supports differentiation and student motivation.

Experiment Type	What It Models	Motor Use	Sonar:bit Use	Real ISS Equivalent
Plant Growth Chamber	A growth chamber that rotates plant samples under simulated light conditions to test growth direction in microgravity.	Slow continuous rotation (simulates centrifuge or rotation for gravity simulation)	Measures proximity to detect when a plant “growth arm” reaches a threshold height	ISS plant growth experiments: Veggie and Advanced Plant Habitat
Material Science Centrifuge	A centrifuge that spins material samples at varying speeds to simulate separation and material behaviour under different g-forces.	Speed-variable rotation (different speeds = different simulated g-forces)	Detects when a sample arm reaches a limit position, triggering an LED data log	ISS material science: alloy solidification, fluid physics experiments
Fluid Dynamics Mixer	A mixing apparatus that combines simulated fluids at controlled speeds to study mixing behaviour without gravity’s influence.	Slow/medium/fast motor cycles (different mixing speeds = different data points)	Proximity sensor monitors whether the mixing arm stays within a safe range	ISS fluid science: combustion research, colloid behaviour studies
Human Biology Monitor	A motion and proximity monitoring system that tracks “astronaut” movement patterns to simulate health monitoring in microgravity.	Motor drives a sweeping arm that simulates periodic exercise equipment operation	Sonar:bit reads “astronaut” distance at set intervals to log activity data	ISS human research: bone density, muscle atrophy, circadian rhythm studies

SMART LEARNING OBJECTIVES

By the end of this lesson, students will be able to:

#	Objective	Domain
1	Design and build a model of a chosen space experiment apparatus using building blocks that physically represents the key components of their experiment type (chamber, centrifuge, mixer, or monitor) with an integrated motor mechanism and Sonar:bit sensor.	Design / Engineering
2	Write and upload a MakeCode program that simulates automated experiment operations: timed motor cycles (representing experimental runs), Sonar:bit data sampling at set intervals (representing measurements), and LED data logging codes (representing transmitted results).	Programming / Technology
3	Explain why their chosen experiment type is scientifically valuable in space, identify the independent and dependent variables of their simulated experiment, and connect at least two principles from physics or biology (microgravity effects, cell behaviour, fluid dynamics) to their design and code.	Science / Knowledge
4	Collaborate in a team of 3–4 across all three days, applying the engineering design process and scientific method, and presenting both the engineering design and the scientific purpose of their experiment clearly to the class.	Collaboration / Communication

SUCCESS CRITERIA (I CAN STATEMENTS)

Students will demonstrate success when they can:

- I can choose an experiment type and explain why that experiment is valuable to conduct in space (microgravity environment).
- I can identify the independent variable, dependent variable, and one control variable for my simulated space experiment.
- I can build an apparatus that physically represents my chosen experiment type with a motor mechanism and Sonar:bit sensor.
- I can write a MakeCode program that runs timed motor cycles, samples Sonar:bit data at intervals, and displays LED data codes.
- I can explain how my code simulates automated data collection and connect it to how real ISS experiments are controlled.
- I can run 3 experiment simulation cycles, record results on a Data Log sheet, and identify a pattern or anomaly in the data.
- I can present my experiment apparatus, scientific hypothesis, programming logic, and simulated results to the class.

KEY VOCABULARY

Introduce these terms using a word wall, glossary cards, or a Quizlet Live activity at the start of Day 1:

Term	Definition	Real-World Connection
Space Experiment	A scientific investigation designed to take advantage of the unique microgravity and vacuum conditions available only in space.	Over 3,000 experiments have been conducted on the ISS across biology, physics, chemistry, and materials science
Microgravity	Near-weightlessness in orbit; the condition where both the station and everything inside it are in continuous free-fall around Earth.	Microgravity allows crystals to grow more perfectly, flames to burn as spheres, and fluids to behave in ways impossible on Earth
Independent Variable	The factor that the experimenter deliberately changes to observe its effect on the outcome.	In a plant growth experiment: light intensity or rotation speed is the independent variable
Dependent Variable	The outcome that is measured and changes in response to the independent variable.	In a plant growth experiment: the direction or rate of plant growth is the dependent variable
Control Variable	The factors that are kept constant throughout the experiment to ensure only the independent variable is causing any changes.	Temperature, humidity, and soil composition are control variables in ISS plant experiments
Automated Data Collection	Using sensors and computers to measure and record experimental data at set intervals without human intervention.	ISS experiments often run automatically for weeks or months while astronauts sleep or do other work
Data Logging	The process of recording sensor readings over time to create a dataset that can be analysed for patterns.	Sonar:bit readings at set intervals simulate the sensor logs that real ISS experiments transmit to Earth
Hypothesis	A testable prediction about the expected outcome of an experiment, based on prior knowledge or reasoning.	Every ISS experiment begins with a hypothesis reviewed and approved by scientists before launch

MATERIALS & RESOURCES

Category	Item	Purpose
Hardware	micro:bit v2 (1 per team)	Main programmable controller for automated experiment operations
Hardware	Nezha Breakout Board V2	Connects micro:bit to experiment motor and Sonar:bit sensor
Hardware	PlanetX Smart Motor	Drives the experiment mechanism (rotation, mixing, sweeping) at varied speeds representing experimental cycles

Hardware	PlanetX Sonar:bit (ultrasonic sensor)	Simulates a measurement sensor that records data at timed intervals during experiment runs
Hardware	USB Cables (1 per team)	Flash programs from computer to micro:bit
Construction	Elecfreaks Bricks Pack (LEGO-compatible blocks)	Physical experiment apparatus: chamber walls, rotating arms, centrifuge structure, mixing paddles, etc.
Software	MakeCode (makecode.microbit.org)	Block-based / JavaScript IDE; timed loops, variable motor speeds, and interval-based Sonar:bit sampling
Classroom	Projector / Interactive Whiteboard	Teacher demonstrations, real ISS experiment video, and code sharing
Classroom	Experiment Type Menu Cards (printed)	One per team — describes their chosen experiment type with key components and programming hints
Classroom	Experiment Design Brief & Data Log Sheets	Scientific planning (hypothesis, variables) and 3-cycle data recording
Optional	Small Plant or Object	Physical prop placed in the apparatus to make the experiment more tangible and visually engaging
Optional	AI Tool (e.g., Claude, ChatGPT)	Research real ISS experiments of the same type; debugging timed loop logic

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LESSON STRUCTURE — 5E MODEL

Total time: 3 × 45-minute class periods. Day 1: Design & Build | Day 2: Programming & Functionality | Day 3: Testing, Iteration & Presentation.

DAY 1: DESIGN & BUILD

ENGAGE — Introduce Context, Spark Interest & Select Experiment Type (15 min)

Time	Activity	Teacher Actions	Student Actions
0–5 min	Entry Task	Display prompt: "Why would scientists bother sending an experiment to space when they could just do it on Earth? What does space offer that Earth cannot?" Students respond on sticky notes.	Write or sketch a response. Post on the class board. These will be revisited in the Explain phase.
5–12 min	ISS Experiment	Play a 3–4 min video of a real ISS experiment: a plant	Watch and note 2 specific observations: (1) what the

	Video	growing in microgravity (NASA Veggie), a flame burning as a sphere (NASA FLEX-2), or a crystal growing in perfect symmetry. Pause and ask: "What is this experiment studying? What would be different if you did this on Earth? What equipment does the astronaut use?"	experiment is doing, (2) what looks different from an Earth-based version. Discuss with a partner.
12–15 min	Experiment Type Selection & Hypothesis	Present the 4 experiment types (see Experiment Type Menu). Each team chooses their type and begins their Experiment Design Brief: "What are you studying? What is your hypothesis? What is your independent variable? What is your dependent variable?"	Teams choose their experiment type. Begin filling in the Experiment Design Brief: hypothesis, independent variable, dependent variable, one control variable.

EXPLORE — Experiment Apparatus Construction (20 min)

Time	Activity	Teacher Actions	Student Actions
0–5 min	Design Brief	Distribute team-specific Experiment Type Menu Cards. Prompt teams: "Your apparatus must: (1) physically represent the key components of your experiment type, (2) include a motor mechanism that runs the experiment cycle (rotation, mixing, sweeping), (3) mount the Sonar:bit to measure the key variable (height, proximity, position). Sketch the full apparatus with all components labelled and the variable being measured identified."	Sketch and label the full apparatus. Identify specifically what the Sonar:bit will measure and what the motor will do during each experimental run.
5–20 min	Apparatus Construction	Circulate with experiment-type specific guiding questions: Plant Growth: "Will the motor rotate the growth chamber at a consistent slow speed?" Material Science: "Can you change the motor speed easily to represent different g-forces?" Fluid Dynamics: "Is the mixing arm central and	Build the apparatus. Builder leads; Coder plans the timed data collection program structure; Recorder documents every design decision; Presenter connects design choices to the experiment's scientific purpose.

		will it reach the full container?" Human Biology: "Does the sweeping arm cover a realistic range of motion?" Encourage scientific accuracy alongside engineering creativity.

EXPLAIN — Space Experiments, Scientific Method & Data Collection (10 min)

Time	Activity	Description
0–5 min	Key Components & Design Comparison	Brief gallery walk or projected share: each team describes one design choice and its scientific purpose. Then introduce the key principles of space experiments: (1) Why microgravity matters — gravity masks many physical and biological processes on Earth; removing it reveals new phenomena. (2) Control is critical — every variable must be identified and managed. (3) Automation is essential — experiments run for weeks unattended; sensors and motors must be reliable and programmable. (4) Data is the product — the goal of the apparatus is not the motion itself but the data it generates.
5–10 min	Scientific Method & Data Logging Connection	Explicitly map the scientific method to the lesson: Observation → ISS video; Question → hypothesis from Design Brief; Prediction → expected Sonar:bit readings; Experiment → 3-cycle simulation on Day 3; Data → Sonar:bit log readings; Analysis → identify patterns in the data; Conclusion → presentation. Connect coding to science: "Your forever loop that reads the Sonar:bit every 5 seconds IS your data collection instrument — just like the automated sensors on a real ISS experiment that transmit readings to Earth every few seconds."

Classroom Management Tip — Day 1 Transitions

- Assign team roles before Day 1: Builder, Coder, Recorder (also Science Officer — tracks variables and data), Presenter.
- The Recorder/Science Officer role is especially important in this lesson — they must complete the Experiment Design Brief and record Sonar:bit readings during testing.
- At the end of Day 1, photograph each apparatus and upload to a shared class folder.
- Print team-specific Experiment Type Menu Cards before Day 1 with the hardware hints included.

DAY 2: PROGRAMMING & FUNCTIONALITY

ENGAGE — Review, Scientific Method Recap & Coding Setup (10 min)

Time	Activity	Teacher Actions	Student Actions
0–5 min	Scientific Method Recap Quiz	Show 3 quick questions: (1) What is the independent variable in your experiment? (2) What will the Sonar:bit measure — and what unit of measurement will you use? (3) What does "automated data collection" mean — and why is it essential for space experiments? Teams confer and answer on mini whiteboards.	Discuss as a team; hold up whiteboard answers. Correct misconceptions about variable types and data collection before coding begins.
5–10 min	MakeCode Setup & Timed Sampling Demo	Demonstrate: connecting the motor and Sonar:bit to the Nezha board. Show a forever loop with two key blocks: (1) a timed motor run (motor on for 3s at experiment speed, pause for 2s, repeat), (2) a Sonar:bit reading every 5 seconds that displays the value on the LED. Explain: "This loop is your automated experiment — the motor runs the experiment cycle, and the Sonar:bit records the measurement at each interval."	Connect hardware; open MakeCode with PlanetX extension. Coder confirms: (1) motor runs at experiment speed for the correct duration, (2) Sonar:bit reads and displays a value every 5 seconds — before writing the full program.

EXPLORE — Code Automated Experiment Operations (25 min)

Time	Activity	Teacher Actions	Student Actions
0–15 min	Core Experiment Program	Display scaffold on board (adapting motor speed and LED codes to experiment type): forever loop → [Experiment Cycle] motor runs at selected speed for 5s → pause 2s → [Data Sample] read Sonar:bit → display reading on LED for 2s → [Log] display a data code ("RUN1", "RUN2", "RUN3") → repeat. For variable speed experiments (Material Science, Fluid Dynamics): add button A = low speed,	Coder writes the automated experiment program. Recorder/Science Officer prepares the Data Log sheet to record Sonar:bit readings during Day 3 testing. Builder monitors hardware connections during initial trials.

		button B = high speed to switch experimental conditions. Circulate and support.	
15–25 min	Data Collection Enhancement & Analysis Setup	Prompt advanced teams: "Can you add a 3-condition experiment: button A = low speed (condition 1), button B = medium speed (condition 2), no button = high speed (condition 3)? Each condition represents a different experimental treatment." "Can you add a data summary on LED: after 3 readings, display whether the average reading is HIGH, MED, or LOW?" "Can you log readings with a counter variable: the LED shows RUN 1, RUN 2, RUN 3 as each cycle completes?" Guide beginners to focus on reliable single-speed timed motor cycle + interval Sonar:bit reading first.	Tune motor speed, cycle duration, and Sonar:bit sampling interval. Advanced teams add multi-condition switching or a run counter. Recorder/Science Officer logs all programming decisions with their scientific rationale.

EXPLAIN — Code Sharing, Data Analysis & Troubleshooting (10 min)

Time	Activity	Description
0–5 min	Code Showcase & Scientific Connection	Each team displays their MakeCode project for 90 seconds. The Coder explains: (1) what the motor cycle represents scientifically in their chosen experiment, (2) what the Sonar:bit reads and how that represents their dependent variable, (3) what the LED data code displays and how that simulates data transmission to mission control. Teacher connects to real ISS: "NASA's Veggie plant experiment on the ISS records growth data automatically using cameras and sensors — your Sonar:bit is doing the same job."
5–10 min	Troubleshooting Circle & Data Logic Discussion	Build a shared "Bug Board" and "Data Board". Bugs: common issues (motor running continuously without pause, Sonar:bit reading too often and flooding the LED, run counter not incrementing). Data discussions: "What does it mean if your Sonar:bit reading decreases over time?" "If you're simulating plant growth, what should your readings show if the plant is growing toward the sensor?" This connects debugging to scientific interpretation simultaneously.

Guided Inquiry Prompts for Teacher Use — Day 2

- "Your Sonar:bit reads every second, which is too frequent for a meaningful experiment — what interval makes more scientific sense for your experiment type, and why?"
- "In a real centrifuge experiment on the ISS, scientists run at multiple different speeds to observe the variable's effect. How could you program 3 different speed conditions into your code?"
- "If your Sonar:bit reading changes between Run 1 and Run 3, what does that tell you about your experiment? Is that the expected result based on your hypothesis?"
- "How would you add a variable counter to your code so the LED shows RUN 1, RUN 2, RUN 3 as each experimental cycle completes?"

DAY 3: TESTING, ITERATION & PRESENTATION

ELABORATE — Experiment Simulation: 3-Cycle Data Collection Run (20 min)

Time	Activity	Description
0–15 min	Full Experiment Simulation — 3 Timed Cycles	Teams run their full experiment program 3 times, using the Data Log sheet as a genuine scientific record. After each cycle: Recorder/Science Officer records the Sonar:bit reading on the Data Log, notes the LED code displayed, and records whether the motor cycle ran correctly. After 3 cycles, the team analyses their 3 data points: "Do the readings change between runs? Is the change what your hypothesis predicted? Can you identify a pattern or anomaly?" Make one targeted improvement to the apparatus or code between cycles 1 and 2, and between cycles 2 and 3.
15–20 min	Advanced Enhancements (Stretch)	Teams that complete 3 successful data cycles choose one enhancement: (A) Add a 3-condition experiment: run at low, medium, and high motor speed and record Sonar:bit readings at each condition — compare whether the variable (Sonar:bit reading) changes with the speed. (B) Program a data summary: after 3 readings, the LED displays "HIGH", "MED", or "LOW" based on the average reading — simulating a processed data report. (C) Add a micro:bit radio data uplink: after each cycle, the experiment micro:bit sends the Sonar:bit reading to a second "mission control" micro:bit that displays it. (D) Build an upgraded specimen holder or container attachment from blocks that better represents the physical experiment apparatus.

Experiment Data Collection Protocol

- Cycle 1: Apparatus and code check — does the motor run the correct cycle? Does the Sonar:bit read and display at each interval? Record: LED code, Sonar:bit reading, and motor behaviour.
- Cycle 2: Data collection — record the Sonar:bit reading from each interval as a data point. Note any change from Cycle 1. Make one improvement before Cycle 3.
- Cycle 3: Final data run — record all readings. Compare Cycle 1, 2, and 3 data: "Is there a pattern? Does it match your hypothesis?"
- Data Analysis: Identify whether readings increased, decreased, or stayed the same. Propose one explanation for any change observed.

EVALUATE — Experiment Demonstrations, Peer Feedback & Reflection (25 min)

Phase	Time	Description
Experiment Demonstration & Scientific Presentation	4–5 min / team	Presenter explains: (1) the scientific purpose — what experiment type they chose and why it is valuable in space, the hypothesis, independent variable, dependent variable, and one control variable, (2) the apparatus design — how each component represents a real experiment part and what the motor mechanism does, (3) the programming logic — how the timed motor cycle and Sonar:bit sampling simulate automated data collection, (4) the results — what their 3-cycle data showed, whether it matched the hypothesis, and one conclusion they can draw. Live 3-cycle experiment simulation runs during the presentation.
Peer Feedback	2 min / team	Audience completes a "2 Stars & 1 Wish" card per team: 2 specific strengths + 1 targeted, constructive suggestion — focussing on either the science, the engineering, or the data. Cards given to presenting teams at end.
Wrap-Up Reflection	5 min	Whole-class discussion: "Which experiment type produced the most interesting or surprising data? Why?" "What would you change about your experiment if you had a third day?" "How does running a 3-cycle experiment with data recording change the way you think about science compared to just demonstrating a model?" "What does this lesson teach you about how real science is done on the ISS?"

DIFFERENTIATION STRATEGIES

Learner Group	Strategy	Concrete Example
Beginning / SEN	Scaffolded tasks with visual supports	Pre-completed Experiment Design Brief with the independent and

		dependent variables already filled in; illustrated coding guide for the timed motor + Sonar:bit loop; visual Data Log template with pre-labelled columns
Beginning / SEN	Reduced scope	Focus on one motor cycle speed only (no multi-condition switching); record just one Sonar:bit reading per cycle; use sentence starters for presentation; annotate printed code instead of writing from scratch
ELL Students	Language support	Bilingual vocabulary card for all 8 key terms; bilingual Experiment Design Brief labels; permit labelled diagrams for variable identification; pair with a bilingual peer
ELL Students	Comprehensible input	Physical demonstrations alongside all verbal instructions; Experiment Type Menu Cards with annotated images; hardware setup cards with annotated connection diagrams
Average Learners	Core task completion	Complete the full timed motor + Sonar:bit sampling program; record and compare 3-cycle data; identify the independent/dependent variable correctly; explain the scientific value of their experiment type in the presentation
Advanced Learners	Open-ended extensions	Add 3-condition experiment with button-controlled speed switching; program a run counter LED display; add a data summary ("HIGH/MED/LOW"); research a real ISS experiment of the same type and compare methods
Gifted / High Ability	Challenge by choice	Add micro:bit radio data uplink to a mission control micro:bit; calculate expected Sonar:bit readings based on their hypothesis before testing; write a brief scientific report comparing their simulation to a real ISS experiment; explore JavaScript view in MakeCode

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ASSESSMENT — FORMATIVE & SUMMATIVE

Formative Assessment (Ongoing — During the Lesson)

Method	When	What to Look For

Entry Task: Why Space?	Day 1, 0–5 min	Surface understanding of what microgravity enables scientifically; identify misconceptions about space experiments
Experiment Design Brief	Day 1, 12–15 min	Check that hypothesis, independent variable, dependent variable, and control variable are correctly identified before building
Design Brief Review	Day 1, Build phase	Assess whether apparatus physically represents experiment type and Sonar:bit placement logically measures the intended variable
Scientific Method Recap Quiz	Day 2, 0–5 min	Verify retention of variable types and data collection rationale from Day 1
Timed Sampling Confirmation	Day 2, Setup phase	Confirm timed motor cycle and interval Sonar:bit reading both work before the full experiment program begins
Science Officer Data Log Review	Day 2, Explore phase	Check that the Recorder/Science Officer is logging programming decisions with scientific rationale — not just technical choices
Code Sharing Spot-Check	Day 2, Explain phase	Verify timed motor cycle, Sonar:bit sampling interval, and LED data codes are all present and logically connected to the experiment type
3-Cycle Data Log	Day 3, Elaborate phase	Assess scientific thinking: do teams compare their data to their hypothesis? Do they identify a pattern or anomaly and explain it?
Exit Ticket (3-2-1)	End of Day 3	3 things learned about space science; 2 variables identified in their experiment; 1 conclusion drawn from their 3-cycle data

Summative Assessment (End of Lesson)

Criterion	Beginning (1)	Developing (2)	Achieving (3)	Exceeding (4)
Design & Build	Apparatus does not represent the chosen experiment type or major components are missing	Apparatus is recognisable but motor mechanism or Sonar:bit sensor placement does not logically match the experiment purpose	Apparatus clearly represents the chosen experiment type; motor mechanism and Sonar:bit sensor are correctly integrated and logically placed	Apparatus is detailed and creative; includes a specimen holder or containment structure; design reflects real ISS experiment constraints

Programming	Code does not run or timed cycles are absent	Code runs but motor timing or Sonar:bit sampling is missing or incorrect	Code runs timed motor cycles and Sonar:bit samples at set intervals; LED data codes display correctly	Code includes multi-condition speed switching, run counter, data summary, or micro:bit radio data uplink
Science Knowledge	Cannot identify the independent or dependent variable; cannot explain why the experiment is done in space	Identifies 1 variable with prompting; gives a vague reason for space-based research	Correctly identifies independent variable, dependent variable, and 1 control variable; explains 2 scientific reasons why this experiment is valuable in microgravity	Connects design, code, and data to a real ISS experiment of the same type; draws a data-supported conclusion from the 3-cycle results
Collaboration	Does not contribute meaningfully across all 3 days	Contributes minimally; the Science Officer role is not fulfilled	All roles fulfilled consistently; Science Officer completes Design Brief and Data Log; all team members contribute to build, code, and presentation	Science Officer leads data analysis and draws the hypothesis-based conclusion; team integrates scientific method thinking into every decision across all 3 days
Presentation	Presentation is unclear; experiment demo does not complete 3 cycles	Presents the apparatus and code with limited scientific explanation; data is mentioned but not interpreted	Explains scientific purpose, variables, programming logic, and data from 3 cycles; live demo runs successfully	Presents with scientific confidence; interprets data meaningfully relative to hypothesis; connects to a real ISS experiment; responds well to questions

TECHNOLOGY & AI INTEGRATION

Tool / Platform	How to Use in This Lesson
MakeCode (makecode.microbit.org)	Primary coding environment; timed loops with pause() blocks for motor cycles; Sonar:bit reading at set intervals using pause() between reads; variable counter for run numbering; JavaScript view for advanced learners
micro:bit v2 + Nezha Board + Motor + Sonar:bit	Full physical computing stack; motor speed represents experimental conditions; Sonar:bit acts as the automated measurement sensor; both integrated in a timed forever loop
micro:bit Radio (Advanced)	Experiment data uplink simulation: experiment micro:bit sends Sonar:bit reading after each cycle; mission control micro:bit displays the received value — mirroring how real ISS experiments transmit data to Earth
AI Chatbot (Claude / ChatGPT)	Students can research real ISS experiments of their type ("What has NASA's Veggie experiment found about plant growth in microgravity?") or ask for debugging help ("Why does my pause block stop the Sonar:bit reading?"). Teach: verify with NASA sources, test code yourself
NASA Experiments Database	NASA's ISS Research and Technology page lists all ISS experiments by category; students can find a real experiment matching their type and compare methods with their simulation
Data Log Analysis (Optional)	Students can transfer their 3-cycle Sonar:bit readings to a simple bar chart on paper or Google Sheets to practice data visualisation — connecting to mathematical data representation

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AI Responsible Use Guidance for Students

- Use AI to research real ISS experiments of your type, debug timed loop logic, or understand microgravity concepts — always verify with NASA or ESA sources.
- Test any AI-suggested code yourself and explain what each block does before presenting.
- When comparing your simulation to a real ISS experiment, be honest about the differences — AI can help identify them, but your analysis must be your own.
- Do not copy AI-written scientific explanations — use them as a starting point and restate in your own words.

REAL-WORLD CONNECTIONS

Connection	Discussion Prompt

NASA Veggie — Plant Growth in Microgravity (ISS)	Astronauts have grown red romaine lettuce, radishes, and chillies on the ISS. Without gravity, plants don't know which way is "up" and must use light for direction. How does your plant growth rotation experiment simulate this challenge — and what would you predict the plant to do?
ISS Combustion Research — Cool Flames	"Scientists discovered that at low oxygen levels in microgravity, fuels can burn at very low temperatures — so-called 'cool flames' — invisible to the human eye but producing chemical products. This discovery could lead to more efficient engines on Earth. How does your fluid dynamics experiment relate to studying combustion behaviour?"
Material Science — Perfect Crystal Growth	"In microgravity, protein crystals grow larger and more perfectly formed than on Earth — helping scientists understand disease proteins and develop better medicines. How does your centrifuge experiment simulate the controlled conditions needed for crystal growth research?"
Human Health Research — Bone Density Loss	"Astronauts lose up to 1% of bone density per month in microgravity without exercise. The ISS Advanced Resistive Exercise Device (ARED) combats this. How does your human biology monitor experiment simulate the tracking of astronaut health data?"
Data Transmission to Earth	"Every ISS experiment transmits data automatically to scientists on Earth via the station's communication systems. A plant growth experiment might send 10,000 data readings per day. How does your Sonar:bit data log simulate this automated, continuous data transmission?"
Future Mars Experiments	"Scientists are already designing experiments to conduct on Mars: how do Martian soil bacteria survive? Can plants grow in Martian regolith? How does your experiment type translate to a Mars mission context — and what would change?"

EXTENSION ACTIVITIES

Activity	Description	Suggested For
Space Experiment Research Report	Research a real ISS experiment matching your team's chosen type (e.g., NASA Veggie for plant growth, ISS ARED for human biology). Compare its apparatus design, data collection method, and results to your team's simulation in a 1-page illustrated summary.	Average & Advanced
3-Condition Experiment Design	Program 3 experimental conditions using button A (low speed), button B (high speed), and no button (medium speed). Run 3 cycles at each condition and record 9 total data points. Create a simple bar chart of Sonar:bit readings vs motor speed. Analyse: does the variable (reading) change with the condition?	Advanced / Gifted

Data Uplink Simulation	Use two micro:bits with radio: the experiment micro:bit sends the Sonar:bit reading after each cycle; the Mission Control micro:bit displays the received value with a run number. Simulate a 6-cycle uplink sequence and record all transmitted values.	Advanced / Gifted
Future Mars Experiment Design	Design a new experiment for a Mars base: what would you study on Mars that you cannot study on Earth or the ISS? Write a 1-paragraph experiment proposal: hypothesis, independent variable, dependent variable, apparatus description, and why Mars is the right location.	All levels
Experiment Analysis & Presentation	Analyse and present the findings of a historical space experiment: choose one ISS experiment, research its hypothesis, method, results, and how the findings have been applied on Earth. Create a 3-minute presentation comparing it to your team's simulation.	All levels
Scientific Report Writing	Write a structured scientific report for your 3-cycle simulation: Title, Hypothesis, Variables, Apparatus (with labelled sketch), Method (step-by-step), Results (3-cycle data table), Analysis (pattern identified), Conclusion (hypothesis supported or not, with reasons).	Gifted

HOMEWORK / FOLLOW-UP TASKS

Task	Instructions	Due
Experiment Reflection Journal	Write 150–200 words: What did your 3-cycle data show — did it match your hypothesis? What was the biggest engineering challenge of making your apparatus simulate a real space experiment? What would you change to make your data more accurate or meaningful?	Next class
Real Experiment Connection	Find a news article or research summary about a real ISS experiment conducted in the last 3 years that matches your experiment type. Write 3 sentences: (1) what the experiment investigated, (2) one similarity between the real experiment and your simulation, (3) one major difference — and explain why that difference exists.	Next class
Extension (Optional)	Design an experiment for a future Mars mission: write a 1-paragraph proposal including your hypothesis, independent variable, dependent variable, and the apparatus you would need. Explain why Mars (not Earth or the ISS) is the best place to run this experiment.	Next class

TEACHER NOTES & TIPS

Before the Lesson

- Prepare 4 different Experiment Type Menu Cards (one per type) with specific hardware hints: which motor speed to use, what the Sonar:bit should measure, and which LED codes to display.
- Test that the motor can physically drive the rotating mechanism for each experiment type at the planned build scale — plant growth chambers may need a lighter attachment than centrifuge arms.
- Pre-install the PlanetX MakeCode extension on all computers.
- Print Experiment Design Brief sheets (with space for hypothesis, variables, and hypothesis-based expected data) and Data Log sheets (with 3 cycle columns and a pattern analysis box) for each team.
- Bookmark NASA ISS experiment videos for each experiment type: Veggie (plant growth), FLEX-2 (combustion/fluid), material science crystal growth, and ARED human health exercise.
- Assign teams to experiment types before Day 1 if you want to balance scientific variety across the class, or allow free choice.

During the Lesson

- The Experiment Design Brief must be completed before building begins — hypothesis and variables must be defined first. This is the key scientific method discipline of this lesson.
- The Recorder/Science Officer role is critical in Lesson 08: they must complete the Design Brief, log programming decisions with scientific rationale, and record all 3-cycle Sonar:bit data. Consider assigning this role explicitly to your most detail-oriented student.
- The timed pause() blocks in MakeCode are the key new programming challenge. Students often forget that pause() stops the entire program, not just one operation. Demonstrate carefully: the motor runs for X seconds, then pauses, then the Sonar:bit reads, then pause, then repeats.
- When teams analyse their 3-cycle data, prompt them to compare to their hypothesis explicitly: "Does your reading going DOWN mean your experiment is working as predicted? What does your hypothesis say should happen?"
- For SEN students, pre-fill the hypothesis and variables section of the Design Brief and focus their energy on the apparatus build and a single-cycle program.
- Encourage cross-type comparisons during the Wrap-Up: "Did the plant growth team and the fluid dynamics team get similar types of data patterns — why or why not?"

After the Lesson

- Collect and photograph all Data Log sheets — these are genuine scientific records and excellent assessment evidence.
- Compile a "Class Experiment Summary": list all 4 experiment types, each team's hypothesis, and their 3-cycle data in one shared document.
- Use reflection journal responses to identify any scientific method concepts (variable identification, data interpretation) that need reinforcement.
- Consider displaying all 4 experiment apparatus models together as a "Space Station Research Lab" exhibit alongside the Lesson 07 space station model.

CURRICULUM STANDARDS ALIGNMENT

Standard Framework	Alignment
NGSS (Next Generation Science Standards)	MS-PS1, PS2, PS3: Physical Science in microgravity; MS-LS1: Life functions in extreme environments; MS-ETS1-1 to 1-4: Engineering Design; NGSS Science Practices 1–8: Scientific inquiry, data collection, and analysis
CSTA (Computer Science)	Level 2 (Grades 6–8): Timed loops, variable motor control, Sonar:bit interval sampling, data logging via LED, run counter variables, and iterative debugging in block-based and JavaScript coding
ISTE Standards (Students)	Empowered Learner, Innovative Designer, Computational Thinker, Creative Communicator, Knowledge Constructor
Common Core (Supporting)	Variable identification and experimental design (mathematical reasoning); 3-cycle data table and pattern analysis; structured scientific oral presentation with evidence-based conclusions
21st Century Skills (4Cs)	Critical Thinking (scientific method + hypothesis testing), Creativity (experiment apparatus design), Collaboration (Science Officer role + team data analysis), Communication (scientific presentations with data evidence)
Series Progression	Lesson 08 deepens the Lesson 07 orbital arc by shifting from station infrastructure to station science; prepares students for Lesson 09

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