Science and Innovation
A Boeing/Teaching Channel Partnership

EXTREME BIOSUITS
Teacher Handbook
Days 6, 7, and 8: How to Build Our Biosuit Models

Lesson Overview

On Day 6, student teams participate in a critical friends tuning protocol to give and receive feedback on their biosuit designs and budget. Student teams then reflect on the peer feedback and decide how to redesign their model to optimize its performance. On Days 7 and 8, students construct their biosuit models to meet all of the criteria for their task assignment and environmental conditions. Additionally, students collaborate to make tradeoff decisions based on a range of constraints—especially budgetary constraints. Students also prepare an accompanying presentation that shows how each feature of their biosuit enables scientists and engineers to comfortably work in extreme conditions.


Connecting to the Next Generation Science Standards

On Days 6, 7, and 8, students make progress toward developing understanding across the following three dimensions:

- **Science and Engineering Practices**: Developing and Using Models, Constructing Explanations and Designing Solutions, Engaging in Argument from Evidence
- **Disciplinary Core Ideas**: ETS1.B Developing Possible Solutions, PS3.B Conservation of Energy and Energy Transfer
- **Crosscutting Concepts**: Energy and Matter, Structure and Function

In the following table, the specific components addressed in this lesson are underlined and italicized. The specific connections to classroom activity are stated.

<table>
<thead>
<tr>
<th>Performance Expectations</th>
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<tbody>
<tr>
<td>This lesson contributes toward building understanding of the following engineering performance expectations:</td>
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<tr>
<td><strong>MS-ETS1-4.</strong> Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.</td>
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<tr>
<td>This lesson contributes toward building understanding of the following physical science performance expectations:</td>
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<tr>
<td><strong>MS-PS3-3.</strong> Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.</td>
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</table>
### Specific Connections to Classroom Activity

The focus of Days 6, 7, and 8 is on MS-ETS1-4. In these lessons, students build biosuit models. On Days 9 and 10, students test their biosuits to generate data for iterative testing. To develop a model biosuit, students must apply their understanding of thermal energy transfer.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>NGSS Element</th>
<th>Connections to Classroom Activity</th>
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<tbody>
<tr>
<td><strong>Science and Engineering Practices</strong></td>
<td>Developing and Using Models</td>
<td>In previous lessons, students developed a conceptual model of their understanding of the human response to stimuli. In this lesson, students build a different kind of model. Students develop a physical model of a biosuit, so they can generate data to test ideas about their designed system. After brainstorming design products in earlier lessons, students begin to engage in the process of designing their biosuit model. When students develop their final presentations, they make an argument, from evidence, about why their biosuit will work and why Boeing should build the biosuit.</td>
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<tr>
<td></td>
<td>Constructing Explanations and Designing Solutions</td>
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<td></td>
<td>Engaging in Argument from Evidence</td>
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<tr>
<td><strong>Disciplinary Core Ideas</strong></td>
<td>ETS1.B: Developing Possible Solutions</td>
<td>Students realize that they must develop a biosuit model so they can test it under simulated conditions. The biosuit model will be useful in collecting data to revise and redesign the model. In later lessons, students test their models. In their models, students attempt to minimize energy transfer between two objects, so they can keep their scientist warm. Students consider the amount and types of material to use in their design to minimize energy transfer.</td>
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<tr>
<td></td>
<td>PS3.B: Conservation of Energy and Energy Transfer</td>
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<tr>
<td><strong>Crosscutting Concepts</strong></td>
<td>Energy and Matter</td>
<td>While designing their biosuit model, students consider the energy transfer from the human body to the surrounding environment. Students attempt to design structures in order to limit the energy transfer. Students consider specific materials that may aid in the limit of energy transfer.</td>
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<td></td>
<td>Structure and Function</td>
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Basic Teacher Preparation

Preparation for this three-day block is the same as that for Days 4 and 5. All required materials must be available and organized for easy student access. Materials should be set up in a secure place in a way that resembles a store, so students can only retrieve materials with the teacher’s permission. In addition, students need a secure location to store their purchased materials and model iterations.

Monitor student teams to ensure team members remain on task and fulfill their team roles to meet daily deliverables.

Refer to the Extreme Biosuits Student Handbook ahead of time so you can address any questions students might have. All Day 6 through 8 documents can be found on pages 28–30 in the Extreme Biosuits Student Handbook. The documents used in this lesson are:

- Feedback Template (page 28)
- Redesign Sketches (page 29)
- Final Presentation (page 30)

<table>
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<tr>
<th>Required Preparation</th>
<th>Links/Additional Information</th>
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<tbody>
<tr>
<td>Gather or purchase the required materials for the lesson</td>
<td>Refer to the Materials List below</td>
</tr>
<tr>
<td>Review suggested teacher preparation resources and the recommended websites</td>
<td>Refer to the Suggested Teacher Resources at the end of this lesson</td>
</tr>
<tr>
<td>Set up the Materials Store</td>
<td>Refer to the Materials List below</td>
</tr>
<tr>
<td>Ensure that appropriate technology is available for students to create their presentations (such as, computers with slideshow software installed)</td>
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</tbody>
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Materials List

All materials available on Days 4 and 5 must also be available on Days 6, 7, and 8.
Day 6: How to Build Our Biosuit Models

Introduction (5 minutes)

Refer students to the Feedback Template on page 28 in the Extreme Biosuits Student Handbook. Give teams 5 minutes to set out their Biosuit Sketches and decide how each member of the team will answer questions from other teams. Remind students that every team member must participate in the feedback question and answer session.

Design Work: Biosuit Critical Friends (40 minutes)

Explain to students that they are going to participate in a critical friends tuning protocol to give and receive feedback. Remind students that when they receive feedback from a visiting team, they do not need to defend their design or verbally respond to the feedback. They are to take notes on the feedback. They have time, as a team, at the end of the feedback session to process their feedback and make team decisions regarding any changes to design, tradeoffs, or budget.

Have student teams rotate to other teams in 5 minute cycles to provide feedback on designs, tradeoffs, and budgets. A timing schedule for the feedback rotations, along with student question prompts is below. Consider posting the questions for students.

- **Presenting Team**: 1 minute to explain their environment, design, budget decisions, and justification based on science ideas.
- **Visiting Team**: 2 minutes for clarifying questions. Each member of the visiting team must ask at least one question. Suggested questions include:
  - *How did you decide what to include in your draft sketch?*
  - *What are your criteria?*
  - *What are your constraints?*
  - *What design tradeoffs have you made? Why?*
  - *What science ideas influenced your decisions?*

- **Visiting Team**: 2 minutes for team members to give suggestions—one suggestion per person—to the team. Guide students to give their feedback starting with, “I’m wondering…” For example, “I’m wondering if your design might be stronger if you put a cuff on the end?” When making suggestions, students should *always* justify their suggestions with science ideas. For instance, the suggestion about the cuff should reference the transfer of thermal energy. During this time, receiving teams do not respond to the “I’m wondering” feedback. They annotate feedback ideas in the Critical Feedback section on their Feedback Template.

- Teams then rotate to another team’s design and repeat the process.

Ideally, teams give and receive feedback to three other teams. Not all teams will get to give and receive feedback to every team. After the three rounds of feedback, teams complete the Team Reflection section of the Feedback Template on page 28 in the Extreme Biosuits Student Handbook and decide on any design changes. Teams then complete the Adjustments and Action Plan section of the Feedback Template.
Lesson Close (5 minutes)

Teams reflect on any design changes they may want to include as part of the feedback cycle. Teams should use page 29 in the Extreme Biosuits Student Handbook to capture their Redesign Sketches.

Helpful Tip

Consider adding an exit ticket that requires team members to rate themselves—and each other—on time management and overall contribution to the project for each day. All ratings should include at least 1 or 2 explanatory sentences.
Day 7: How to Build Our Biosuit Models

**Introduction (5 minutes)**

Have student teams complete a team role check-in, in which each team member describes what they plan to accomplish during today’s build time. Each team member should review their identified tasks for completion and share with the group any challenges or assistance needed.

Be sure to remind the class that ALL students should contribute to ALL tasks, even though one individual may be in charge of certain tasks. For instance, the team marketing manager should not develop the presentation alone. All student input is necessary.

**Design Work: Biosuit Build (40 minutes)**

Groups continue to construct their biosuit models. Students should also begin to work on their biosuit presentations as outlined in Final Presentation on page 30 in the Extreme Biosuits Student Handbook. During this time, monitor each team by checking in with team members and asking clarifying questions regarding their next steps and task list for the day. Also ask groups questions that focus on the science ideas, criteria, and constraints included in their designs.

Examples of questions include:

- Why did you decide to use x?
- Why did you decide to include the y feature in your design?
- What science idea impacted your decision to include z?
- How will your biosuit minimize energy transfer from the scientist or engineer to the local environment?
- How will your biosuit protect your scientist or engineer?

**Helpful Tip**

Consider having students track individual contributions using a time-tracking chart.

**NGSS Key Moment**

Make sure the key science ideas of response to stimuli and thermal energy transfer are central in the design process. If students begin to lose sight of these ideas, refocus them through guiding questions. At this point in the design process, students should be building on their understanding of science ideas to develop a design product (the biosuit).

**Helpful Tip**

Consider posting anchor charts in the classroom to ensure students have the science in mind. For instance, an outline of the human body with some critical systems could invite teams to post notes with ideas about protecting those systems and how they relate to one another. Another chart could gather teams’ ideas about conducting and insulating materials.
Lesson Close (5 minutes)

Teams continue to manage their budgets and continue purchasing materials as needed. They should also check to see which tasks are on track and which will need special attention during the next lesson.

Helpful Tip

Have team members create a checklist of what they accomplished today, and what they still need to accomplish to finish their deliverables during the next two class sessions.
Day 8: How to Build Our Biosuit Models

Design Work: Biosuit Build (35 minutes)

This session provides students with a second day to design their models and prepare their presentations. The day’s activities should generally mirror Day 7.

Extension

Consider adding the requirement that teams must supply data showing that their biosuit works. Students can design their own investigations to collect data on their biosuit design.

Design Work: Design Decisions (15 minutes)

To conclude the design work, instruct students to independently write a paragraph justifying their team’s design choices. Students should refer to their Defining the Problem and Identifying Solutions (Rounds 1–3) charts on pages 13, 16, and 23 in the Extreme Biosuits Student Handbook, and Final Presentation on page 30 when crafting their final arguments. Consider using the Argument Scoring Guide (see Appendix D) to assess student arguments.

Assessment

Several opportunities for formative assessment exist in this lesson:

- Extreme Biosuit Student Handbook entries can be used to monitor student progress during the module. For this lesson, focus specifically on the Redesign Sketches (page 29).
- Monitor student progress using student justifications for design choices. Consider using the Argument Scoring Guide (see Appendix D) to assess student arguments.
- Consider gathering evidence of student progress through small group and whole group discussions.

Use the identified assessment opportunities to monitor student progress on disciplinary core ideas, science and engineering practices, and crosscutting concepts. Provide appropriate supports or extensions when necessary.

Reference Appendix B for suggestions for meeting the needs of all learners.

Community Connections

Have students ask their parents, guardians, or adult family members if they have ever worked on a project at work where they collaborated with a team. Have students ask about the challenges and benefits of collaborative teamwork.
## Suggested Teacher Resources

<table>
<thead>
<tr>
<th>Resource</th>
<th>Location</th>
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<tbody>
<tr>
<td>Meeting the Needs of All Learners</td>
<td>Extreme Biosuits Teacher Handbook, Appendix B</td>
</tr>
<tr>
<td>Argument Scoring Guide</td>
<td>Extreme Biosuits Teacher Handbook, Appendix D</td>
</tr>
<tr>
<td>Extreme Biosuits Student Handbook</td>
<td>[Resource Link]</td>
</tr>
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