Part III

Introduction

Integrating Science and Technology

Construct-a-Glove is aligned with the National Science Education Standards for process and content standards in both physical science and biology, as shown in the Standards and Benchmarks Connections table later in this section. Through inquiry and design, students develop conceptual understanding of heat energy transfer, cell metabolism, and thermal regulation. Because design activities motivate inquiry and inquiry informs design, students engage in the iterative processes of scientific inquiry and technological design through a variety of hands-on activities.

Schedule

The minimum time needed to complete the core unit is about 12 class sessions. More time will be needed if you choose to include the enrichment activities.

In Construct-a-Glove, students are given the Design Brief challenge and instructions for making a quick-build insulated glove (about three class sessions). During the research and development phases (a minimum of seven class sessions), students identify relevant factors and variables, design and conduct experiments, and contribute to a product development team. They develop a physical model of their design, test, measure, analyze their data, and redesign if necessary. Students search for combinations and configurations of materials that can improve the performance of their prototype glove. Teams critique each other’s prototypes and learn to build on the experience and insights of other groups. In the Communication activity (two class sessions), the team composes a product prospectus.

Key Ideas

Each key science idea used in Construct-a-Glove is covered in a text reconstruction exercise in Appendix B (p. 265). The first exercise, on homeothermic processes, involves a very simple reconstruction and is intended as an introduction to text reconstruction.

Homeothermic Process (Maintaining a Constant Internal Body Temperature)

The measured and perceived warmth of a hand is related to its direct connection to the body’s heat engine and the hand’s relatively large ratio of surface area to volume. Variables that add complexity to an insulated glove system design relate to the multiple functions of the hand: an appendage for body cooling, environmental sensing, and manipulating objects.

Heat Energy Transfer Processes, Insulation Materials, and Dexterity

Student teams measure temperature change over time as a gloved hand is exposed to cold. Properties of various materials are explored for their effect on hand warmth and dexterity.
**Inquiry and Design**
Experiments are designed by students to supplement “fair test” comparisons of several manufactured gloves. Students conduct “hands-in” research to determine combinations of glove materials that balance thermal effectiveness with dexterity for a specific function. Working in development teams to design and construct an insulated glove system prototype, students present their research and development effort in a product prospectus.

**Student Portfolios**
The following items can be accumulated in portfolios for summative assessment:
- Pretest: Snapshot of Understanding
- Initial questions: Design Brief
- Individual information search
- Brainstorming record: Identifying Factors and Variables
- Problem statements: Team Situation Analysis
- Research and results: Investigating Heat Transfer and Insulation; “Fair Test” Comparison
- Group process description: Inquiry Process and Design Process
- Development Assignment
- Team Feedback
- Evaluation of prototype: Reflections on Design
- Group summary documentation: Creating a Product Prospectus
- Posttest and self-assessment: Snapshot of Understanding
### Standards and Benchmarks Connections

<table>
<thead>
<tr>
<th>Task</th>
<th>Source</th>
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<tr>
<td>Students build to specifications and observe and measure thermal performance of a simple insulated glove system. <strong>Standard/Benchmark:</strong> Materials and Manufacturing; Systems; Manipulation and Observation; Physical Science Content; Life Science Content; Unifying Concept: Evidence, Models, and Explanation</td>
<td>AAAS 9–12, NSES 9–12, NSES K–12</td>
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<tr>
<td>Students conduct independent information searches in context of contemporary human inventiveness. <strong>Standard/Benchmark:</strong> Issues in Technology; Nature and History of Technology Science, Technology, and Society</td>
<td>AAAS 9–12, ITEA 9–12, NCSS VIII</td>
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<td>Students describe variation and identify variables and corresponding potential controls for improving design to meet performance goals. <strong>Standard/Benchmark:</strong> Systems; Manipulation and Observation; Technological Design; Unifying Concept: Evidence, Models, and Explanation</td>
<td>AAAS 9–12, ITEA 9–12, NSES K–12</td>
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<td>Students use elements of inquiry, investigating heat transfer and insulation, to inform design. <strong>Standard/Benchmark:</strong> Scientific Inquiry; Design and Systems; Inquiry; Technological Design; Utilizing and Managing Technological Systems</td>
<td>AAAS 9–12, ITEA 9–12, NSES 9–12</td>
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<td>Students use “fair test” comparisons to quantify relative handwear performance parameters. <strong>Standard/Benchmark:</strong> Critical-Response Skills; Physical Science Content Standard; Life Science Content Standard; Unifying Concept: Constancy, Change, and Measurement; Technological Design; Linkages</td>
<td>AAAS 9–12, ITEA 9–12, NSES 9–12 and K–12</td>
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<tr>
<td>Students conduct research on human homeothermic regulation and hand function as input to glove system design. <strong>Standard/Benchmark:</strong> Basic Functions; Life Science Content Standard; Unifying Concept: Form and Function</td>
<td>AAAS 9–12, NSES 9–12 and K–12</td>
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<td>Students communicate orally and in writing their interpretation of this investigation and what variables to control in design development. <strong>Standard/Benchmark:</strong> Scientific Inquiry; Technological Design; Math as Communication; Statistics</td>
<td>AAAS 9–12, ITEA 9–12, NCTM II</td>
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<td>Students apply abilities of iterative technological design, including brainstorming, research, ideation, choosing among alternative solutions, development, implementation, and evaluating consequences. <strong>Standard/Benchmark:</strong> Technological Concepts and Principles; Technological Design; Developing and Producing Technological Systems; Systems Operation and Feedback; Abilities of Technological Design; Unifying Concept: Systems, Order, and Organization</td>
<td>AAAS 9–12, ITEA 9–12, NSES 9–12 and K–12</td>
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<td>Task</td>
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<td>Students use tools and processes to construct and modify working models. <strong>Standard/Benchmark:</strong> Developing and Producing Technological Systems</td>
<td>ITEA 9–12</td>
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<td>Students collect, represent, and statistically process test data to improve design prototype. <strong>Standard/Benchmark:</strong> Manipulation and Observation; Utilizing and Managing Technological Systems Statistics</td>
<td>AAAS 9–12, ITEA 9–12, NCTM X</td>
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<tr>
<td>Students create detailed product specifications and manufacturing instructions for their final design. <strong>Standard/Benchmark:</strong> Design and Systems; Manipulation and Observation; Math as Communication</td>
<td>AAAS 9–12, NCTM II</td>
</tr>
<tr>
<td>Students communicate quantitatively the technical construction specifications and performance characteristics for their prototype in a product prospectus. <strong>Standard/Benchmark:</strong> Communication Skills; Design and Systems; Technological Design; Math as Communication</td>
<td>AAAS 9–12, ITEA 9–12, NCTM II</td>
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<tr>
<td>Students articulate principles of biological and physical science used in glove system design. <strong>Standard/Benchmark:</strong> Critical-Response Skills; Science and Technology; Technological Design Linkages</td>
<td>AAAS 9–12, ITEA 9–12, NSES 9–12</td>
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<td>Students self-assess their learning by comparing pre- and post-Snapshots of Understanding. <strong>Standard/Benchmark:</strong> Issues in Technology; Science, Technology, and Society</td>
<td>AAAS 9–12, NCSS VIII</td>
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**Source Key:**


Course Outline

Introduction
- Overview: Insulated Glove Design Brief
- Snapshot of Understanding

Quick-Build
- Overview: Quick-Build Insulated Glove
- Identifying Factors and Variables
- Team Situation Analysis: Reflections on Your Quick-Build

Research
- Overview: Research
  » Team Assignment
  » Individual Research Report
- Investigating Heat Transfer and Insulation
- “Fair Test” Comparison

Development
- Overview: Development
- Development Assignment
- Team Feedback
- Reflections on Design

Communication
- Overview: Communication
- Creating a Product Prospectus
- Snapshot of Understanding
OVERVIEW: INSULATED GLOVE DESIGN BRIEF
In this activity you will be researching, designing, building, and improving an insulated glove system. You will use both technological design and scientific inquiry as processes to investigate and improve the performance of your prototype.

Design Challenge
As a member of a product research and development team, design an insulated glove system that keeps the tip of your index finger as warm as possible in uncomfortably cold surroundings, while maintaining dexterity for a specific function.

Scope of Work
- **Quick-Build:** Build and test an initial glove design according to instructions, and identify variables you can control to create an improved insulated glove.
- **Research:** Investigate heat transfer and insulation, and conduct a “fair test” comparison.
- **Development:** Specify function, redesign, build, and test; collect data and analyze patterns of results; then finalize your prototype for critical review.
- **Communication:** Present a product prospectus that summarizes your team’s final design, including documentation such as sketches, data, specifications, and limitations.
SNAPSHOT OF UNDERSTANDING
What I Already Know About Homeothermy, Heat Transfer, and Research and Development

The unit of study you are about to begin will challenge you to design, build, and performance test a prototype model of an insulated glove. To meet the performance specifications, you will have to investigate heat transfer physics, biological temperature regulation, and insulative effectiveness of materials and configurations. Before you begin, record a sample of what you already know by answering the questions below. This is not a test; rather it is a series of questions that ask about your current knowledge of key ideas in this unit. At the end of the unit, you will answer similar questions and compare what you have learned.

1. What are the parts of the hand?

   a. What are the functions of a hand (e.g., sensing, temperature regulation, manipulation)?

   b. Make a sketch of a hand and label the important parts and functions.
2. List as many special-purpose kinds of gloves as you can. Place a “T” by those specifically designed to provide thermal protection. For example, a welding glove is designed to provide thermal protection so you would put a “T” next to “welding” in the list.

3. Think of a time when your hands were really cold. What were you trying to do?

   How did you warm them?

   Which heat transfer process did you use? (e.g., radiation, conduction, convection)
4. What test(s) could you perform to determine if an animal is “warm-blooded” (homeothermic) or “cold-blooded” (poikilothermic)?

5. To maintain your relatively constant body temperature of 36°C, what does your body do automatically?

   What are some things you do purposefully to make yourself warmer or cooler?

6. What are *temperature* and *heat*, and how are they related?
OVERVIEW: INSULATED GLOVE DESIGN BRIEF
Give students the Insulated Glove Design Brief and the Snapshot of Understanding. Initiate class discussion and highlight important design issues. In the Snapshot of Understanding, students write short answers to questions about their prior knowledge of heat transfer, body temperature regulation, and research and design processes.

Preparation
- Read and become familiar with the entire unit.
- Photocopy student activity sheets for distribution.
- Prepare an introduction to motivate student interest.
- Define your assessment system with a clear, simple description.

Materials
- Student Activity Sheets
  » Course Outline
  » Overview: Insulated Glove Design Brief
  » Snapshot of Understanding
- Ring, Pocket, or Folio Binder (student supplied; for keeping student activity sheets, notes, and drawings for reference and portfolio assessment)

Time Requirement
This activity requires one class session. Completing the Snapshot of Understanding takes about 20 minutes.
Teaching Suggestions

Introduction
Hand out the Insulated Glove Design Brief student activity sheet. Ask students to keep these and future sheets together and to bring them to the classroom with other notes to serve as a record and reference for daily activity (and assessment) in the unit. Advise students that they will work in teams, using processes of technological design and scientific inquiry, and that other teams will critique their prototype with respect to the challenge criteria.

Students are also required to document their activity in order to contribute effectively to the final team presentation and enhance their individual portfolios. Be clear on your rubrics for assessing their work and share them with students. Indicate which activities will be individually graded and which will be given a team score. Be prepared to justify team scoring if some students (or parents) are not used to the idea.

Issuing the Construct-a-Glove Challenge
We encourage you to expand the challenge to accomplish additional learning objectives, but be careful to think through what will be involved. For example, a criterion of dexterity (such as the ability to pick up a marble with the insulated glove system) might be added to enrich the challenge if robotics or finger function is pertinent to your course objectives. But this addition will demand more sophisticated technical materials, involve greater construction difficulties, and require more student time.

Here are some other possible criteria for this challenge:

- Let students specify the dexterity they have achieved after the fact, in their product prospectus.
- Let teams choose to design for one of several simulated bid invitations. You will need to prepare the bid request document (be sure to include dexterity task specifications).
- Set one uniform standard for all teams to achieve with the gloved hand immediately following a standardized immersion time in ice water. Example
tasks include picking up a pencil off a flat surface, operating a camera, using pliers, holding a nail for hammering, tuning a radio, opening a keyed lock, and placing a nut on a bolt.

- Set a theme such as survival in snow country. If you use this theme or a similar outdoors survival theme, orient the challenge toward natural insulation materials such as leaves and grasses that can be gathered outdoors, and specify necessary hand functions such as gathering firewood and signaling for help. (Define or supply the range of options so as not to damage the local environment.)

**Preassessment**

Hand out the Snapshot of Understanding. Emphasize that it is not a test and that students will not be graded on this activity. The purpose of the Snapshot is self-diagnostic—to find out what students know initially about the key science and technology learning objectives of Construct-a-Glove.

An inventory of students’ prior knowledge is an important teaching and learning tool. Not only does the inventory help guide students toward the concepts they need to learn the most, but it also prepares them to accept new information in a manner that ties meaningfully to what they already know. At the end of Construct-a-Glove, students will be able to compare answers to Snapshot questions given at the beginning of the unit with those they will answer at the end of the unit.

In the Snapshot of Understanding, students list as many special-purpose gloves as they can, given one example (welding). Here are some additional examples: food handling, meat cutting, dish washing, staining/painting/waxing, gardening, wood cutting, handling chemicals, working on electrical lines, firefighting, driving, traffic directing, fashion, surgery, cattle roping, archery, baseball, boxing, diving, golfing, hockey, hunting, ice fishing, mountain biking, mountain climbing, skiing, and spacewalking.

Encourage a class discussion of differences among special-purpose gloves; this can help students better relate form to function.