APOLLO 13

The Launcher Unit

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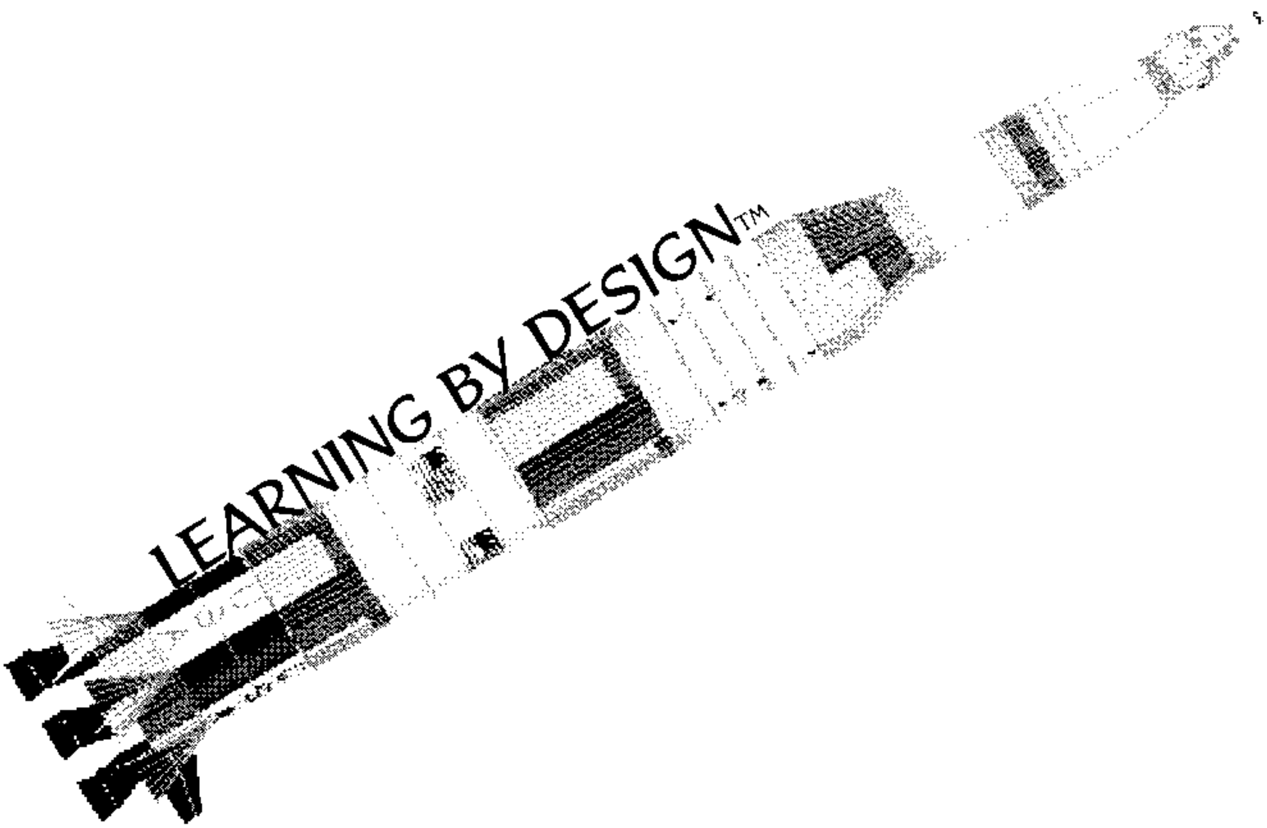

This project was supported in part by the National Science Foundation, the McDonnell Foundation, BellSouth Foundation, and the Woodruff Foundation. Opinions expressed are those of the authors and not necessarily those of the sponsors.

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Welcome to Learning By Design™

As a student, you've probably experienced many different types of classrooms. You've probably thought about what it means to go to school and take part in classroom activities. In the Learning By Design™ classroom things might be a little different from what you're used to. In other classes you may read a textbook and take quizzes or tests based on the information that you read. In the Learning By Design™ classroom you will experience and "do" science rather than just read about it. Our hope is that you will not only learn science concepts and processes but that you will have fun doing it.

The Learning By Design™ team at Georgia Tech has developed this introductory physical science unit – Apollo 13 – to familiarize you with a new way of doing science. You'll learn some new science and design terminology, some new (but probably familiar) experimental methods, and ways of working together in teams that will benefit you as a student in all of your classes.

Apollo 13: The Launcher Unit is divided into four major sections. Section One is the Design Challenges. You will work together in teams to meet these challenges. In this section you will notice pointers (a box with a finger in it) to sections Two and Three. Section Two has science content explanations and Section Three has science process (how to 'do' science) explanations. You will want to refer to these pages whenever you need to understand the science involved in a challenge or you need a reminder of how to do a certain science or design practice. For example, when you are designing a book support in Section One, you will want to read the Section Two pages on the Science of Structures so that you can understand the "why" and "how" of the mechanics of the book support. Also, you'll want to read the Section Three pages on Gallery Walks, Design, Collaboration, and Copying vs. Credit. These are all important aspects of this challenge. Each challenge has its own pointers so be sure to go to them - they will help you achieve the challenge. In addition, you will notice LBD™ cycle icons (pictures) in the upper left corner of some pages. These pictures will help you to notice which part of the process you're in at any given time, either Design or Investigation. Each of these individual cycles have their own parts as well. You can see a picture of the entire cycle and how it fits together at the end of Section Three. Section Four is the Design Diary pages. You will see pointers to these as well. You will use these to keep track of your work and keep written records of what you've done, just like a true scientist does.

Learning By Design™ curriculum units are designed, based on research, to make science learning interesting, informative, and fun. We hope that you enjoy Apollo 13.

Goals for the Apollo 13 Unit

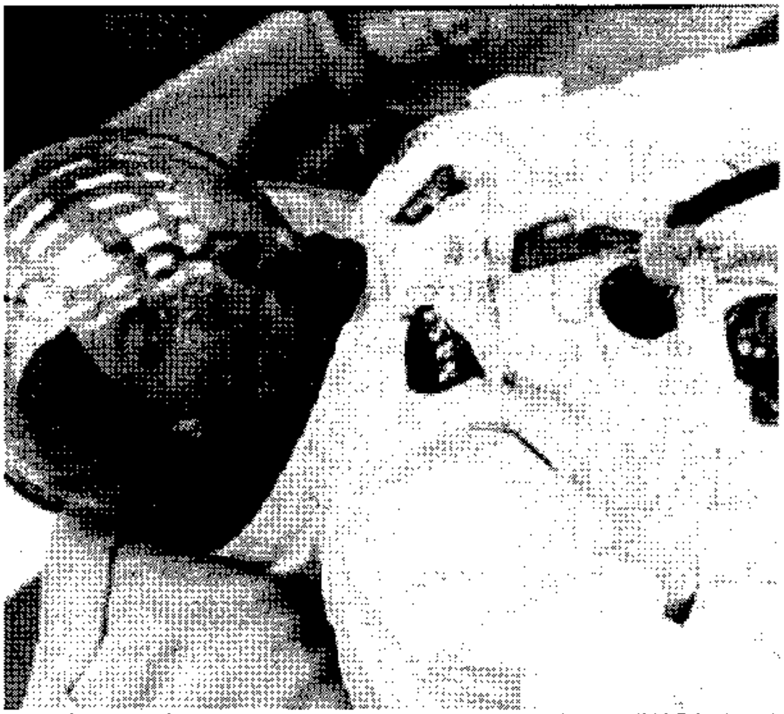
The drama of the Apollo 13 mission helps us to appreciate some of the things about science and technology that we tend to take for granted. It also shows us how science, technology, and design are related.

During the four days following an accident, the support crew of Apollo 13 had to anticipate as many problems as possible and solve them with the limited resources available to the crew out in space. The astronauts and ground crew worked together to figure out how to navigate the craft precisely, how to filter the air, how to return power to the craft, and how to work without crucial instruments. There were many other potential problems that they would not have been able to solve. No one knew if the heat shield on the command module had been damaged in an explosion. If it had, the astronauts might burn up as they returned to earth. No one knew if the parachutes would deploy properly after they had been unwarmed for four days. But the astronauts and the ground crew designed solutions for every problem within their control.

On April 17th, the crew prepared for return to earth's atmosphere. After returning power to important systems, they jettisoned the service module. With less than two hours until re-entry, they moved back into the command module and released Aquarius. As the astronauts finally entered earth's atmosphere, the heat shield on the command module remained intact, and the parachutes deployed perfectly. Their safe return was accomplished just barely before their oxygen ran out.

In the upcoming weeks you'll be designing, planning, and building structures and parachutes. You will also design and run experiments. You'll find out what it takes to make a good decision. You'll learn how to observe carefully and estimate accurately. You'll find out that good decisions come from generating several alternatives, weighing the pros and cons of each, adapting each to make it more advantageous, and finally, choosing the "best." You'll learn science facts and science skills as ways of tackling hard problems.

Sometimes you'll work as individuals, sometimes in small groups, and sometimes the whole class will share ideas with each other, much as you'll see scientists and engineers doing in the film.



Jack Swigert, Command Module Pilot prior to launch (NASA photo)

Goals for the Apollo 13 Unit (cont.)

Project Skills & Reasoning Skills

Breaking down a problem
Information gathering
Collaboration
Communication
Designing products for people
Documenting the design process
Reasoning with cases
Identifying criteria and constraints
Iteration: design, test, and refine
Making and justifying decisions
Representation and sketching
Understanding devices
Careful fabrication

Mission Control Center during the Apollo 13 oxygen cell failure (NASA Photo)

Science Skills

Designing experiments
Observation
Measurement
Inquiry
Estimation
Following a procedure
Fair tests
Managing variables

Technology Skills

Describing products
Describing how things work
Structure, function and behavior of devices
Designing artifacts
Product history
Product comparison

What is Design?

You'll be doing lots of designing in the Learning-by-Design™ units. But what, exactly, is design, and what will you be doing?

To construct your own initial understanding of design, it might help to think about the things in the world around you and the people who conceive of those and figure out how to make them work. We call those people designers. Architects are designers of buildings. Civil engineers design bridges and sewer systems. City planners design the layout of cities and towns. Interior designers plan the look and layout of the inside of a building. Industrial designers figure out the shape and packaging of machines and consumer products. Mechanical engineers design mechanisms for devices. Electrical engineers design the insides of computers. There are even designers involved in putting your textbooks together -- they decide how to lay out the pages, what the type should look like, and how to present the material so it is easy to scan.

In general, designers make decisions about the "best" mechanisms to use to make an artifact or device perform its function and the "best" way for it to look. Often, several designers work together on a project, each contributing a different kind of expertise to the decision making. For example, designing hairdryers requires an industrial designer to figure out the shape the hairdryer should have and a mechanical engineer to design the mechanisms that make it work. Usually, designers make good decisions. Sometimes they don't. When you find a device or artifact that's hard to use or doesn't look pleasing, you feel like the designer didn't do his or her best job. Maybe they didn't consider the ways people would use it; maybe they decided to use poor-quality materials or craftspeople who weren't good enough.

But often, even though you don't like the way something turned out, it was the best that could be done within the limitations of the time or resources or knowledge available. For example, automobiles and airplanes work and look quite different today than they did when they were first invented. It isn't because those original designers did a poor job. They did the best they could given the materials, tools, and knowledge of their time. Now that we know more about aerodynamics and about creating and working with lightweight materials, airplane and automobile designers are able to make different decisions than they could back then, resulting in planes and cars looking and working quite differently than they did in the beginning.

A good designer needs to (i) know how to make good decisions, (ii) be able to identify things they need to find out more about and new concepts they need to learn, (iii) be creative in coming up with ways of testing ideas and alternative solutions, (iv) be able to analyze the implications of those tests and make new decisions based on those, and (v) be quite comfortable and patient with debugging and refining early ideas several times before calling a design complete. A good designer also needs to know when a design is good enough, that is, when the time needed to make it better isn't worth it because it won't get enough better to make an obvious difference.

What is Design? (cont.)

Designing is fun, engaging, and rewarding. It can be thrilling to take an idea you've imagined and make it work -- to have an idea that perhaps nobody else has ever had and to go from that idea to creating a real physical device that works and that others can use. Transforming a vision into reality requires guts, especially when the vision is new and different. It requires collecting evidence that convinces you that your idea is workable and that you can use to convince others. It requires seeing the big picture and having enough know-how and evidence to trust it without knowing all the details, and then it requires digging into those details and making them work.

Let me use a personal example to illustrate. Taking Learning by Design™ from an idea to an almost-working curriculum, and then taking it from there to this textbook and the others you'll be seeing, has been one of the most thrilling things I've ever done. Some people had confidence that I could get together a team to do it; most people admired what I was trying to do but laughed at how ambitious I was and told me that what I wanted to do was too hard. I had the evidence I needed that the idea could work, and that gave me the confidence to take on the project. But moving from the ideas to the details of how to make it work has been far harder than I imagined -- probably the most difficult project I've ever worked on. For example, we struggled and struggled over how to structure design projects so that they would be focused on the science but still have enough flexibility for students to have an engaging challenge to work on.

The thrill in designing comes from encountering challenges, working hard to overcome them, and finally succeeding and making something work.

The designs you will work on are small compared to the challenges professional designers take on. They are the right size, I hope, for a middle schooler learning science. I hope you'll feel some of the same thrill professional designers feel when you engage in LBD™ design challenges, grapple with the issues, try out your ideas, and persevere to overcome the challenges -- by learning more and refining your ideas over and over again and finally succeeding.

The LBD™ series isn't finished yet. I'm looking forward to making this book better and to helping create many more. I'll look forward to feedback from any of you who want to provide constructive criticism -- about the book, about the activities, about what might work better, or about anything you think would help our team in its design task. Write down your comments, and give them to your teacher. She or he will forward them to us.

On behalf of the whole LBD™ team, thank you in advance, and have fun designing and learning.

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