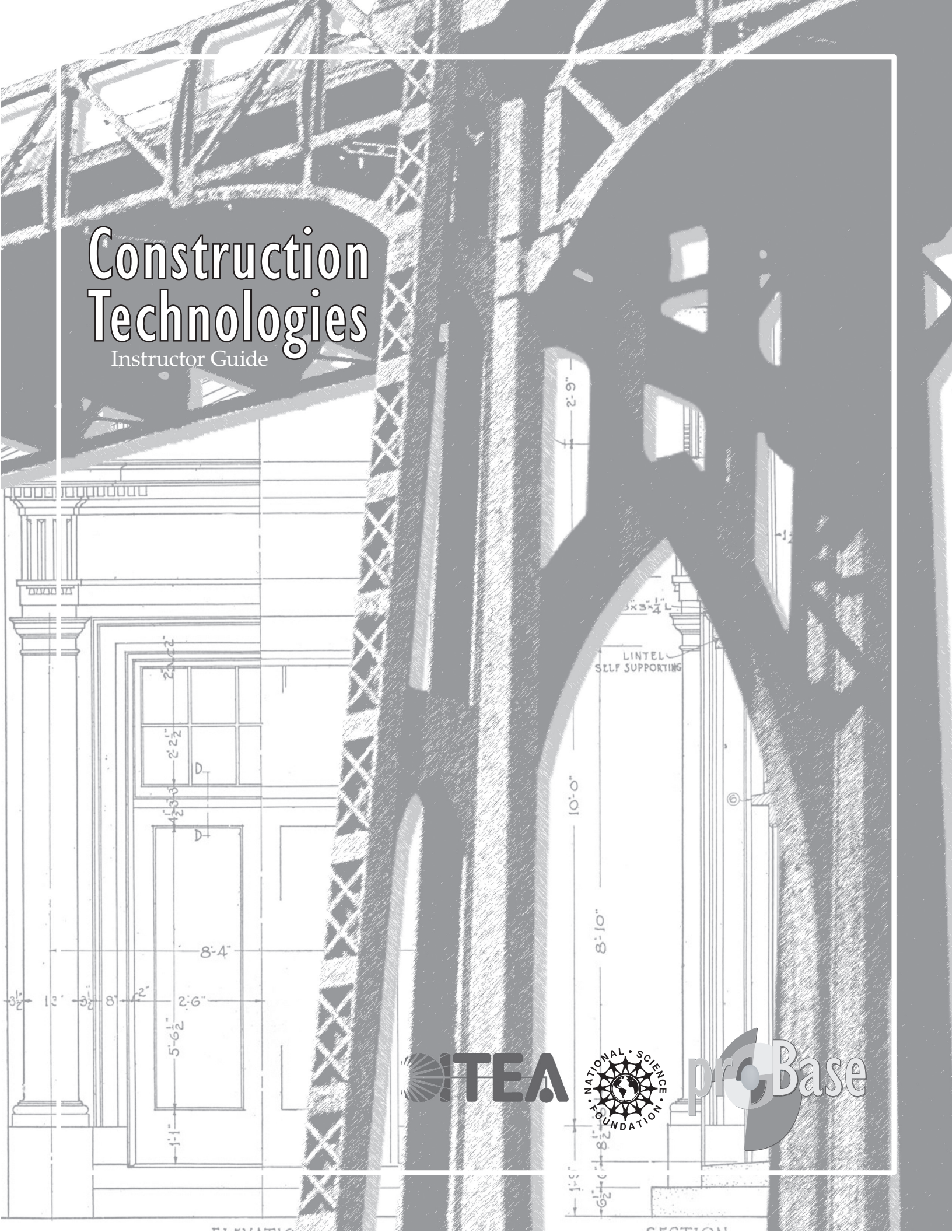
Construction Technologies

Instructor Guide



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Advanced Technological Education

International Technology Education Association
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Learning Unit Overview

Learning Unit Purpose

As our nation's economy, society at large, and environment are increasingly influenced by technological innovations, it is imperative that our educational system is able to keep pace and is able to prepare students for highly technical careers. This Project ProBase Learning Unit, titled *Construction Technologies,* is designed to help prepare high school students who plan to go on to community college technical education or university-level engineering programs.

This unit is one of eight Learning Units developed by Project ProBase to address the critical need for upper high school technology education curriculum. The Project ProBase Learning Units utilize hands-on, problem-based activities to introduce fundamental technology concepts related to each context area standard identified in *Standards for Technological Literacy: Content for the Study of Technology* published by the International Technology Education Association.

You may be interested in the other Learning Units developed by Project ProBase:

- *Agriculture and Related Biotechnologies*
- *Construction Technologies*
- *Entertainment and Recreation Technologies*
- *Energy and Power Technologies*
- *Information and Communication Technologies*
- *Manufacturing Technologies*
- *Medical Technologies*
- *Transportation Technologies*

Constructivist-based Teaching and Learning

Each Learning Unit is driven by authentic open-ended problems offering multiple opportunities for students to construct knowledge about the world around them. Constructivism is a learning theory based on the belief that humans learn best when they construct their own knowledge based on their experiences.

One goal of the ProBase Learning Units is to provide a variety of authentic, contextually-based experiences that students can use to construct accurate knowledge and develop appropriate skills across the contexts of technology. Constructivist learning is accomplished by providing experiences and opportunities that encourage students to construct accurate knowledge. Each Learning Unit considers the student as a creator of knowledge and assumes that the teacher will facilitate this acquisition of knowledge. This is contrary to the notion that teachers are "dispensers" of knowledge and requires a paradigm shift for some.

As facilitators of learning, ProBase instructors will need to prepare for class in a slightly different way. Students will still need materials and equipment as they engage in activities.

Instructors should review all of the learning cycles in advance so that they know what materials and equipment to gather as well as what types of demonstrations must be provided. Another important reason for reviewing the learning cycles is to begin thinking about appropriate questions to ask the students. Sample questions are provided in the *Reflection* phase of each learning cycle. However, the instructor may want to go beyond these questions to probe student thinking to find out the technological perspective students bring to the class. The instructor should ask questions that challenge student thinking and present new ideas that help students create conceptual change.

Connecting Standards for Technological Literacy: Content for the Study of Technology

Enduring Understandings

Each Learning Unit developed by Project ProBase was developed to address three to four enduring understandings derived from *Standards for Technological Literacy: Content for the Study of Technology* (STL) published by the International Technology Education Association (2000/2002). According to Wiggins and McTighe in *Understanding by Design* (1998, p. 10), an enduring understanding "refers to the big ideas, the important understandings, that we want students to 'get inside of' and retain after they've forgotten many of the details."

In an effort to distill the enduring understandings from STL, each standard was filtered through the following questions:

- Does the standard represent a big idea having enduring value beyond the classroom?
- Does the standard reside at the heart of the discipline?
- Does the standard require uncoverage of abstract and often misunderstood ideas?
- Does the standard offer potential for engaging students?

This process yielded nine enduring understandings. For a complete list of enduring understandings along with corresponding essential questions, see appendix page AA.

Students will understand:

1. That technological progression is driven by a number of factors, including individual creativity, product and systems innovations, and human wants and needs.
2. That technological development for the solution of a problem in one context can spinoff for use in a variety of often unrelated applications.
3. That technological change can be positive and/or negative and can have intended and/or unforeseen social, cultural, and environmental consequences.
4. How technological systems work, the components of those systems, and how they fit into the larger technological, economic, and social systems.
5. The compelling and controversial issues associated with the acquisition, development, use, and disposal of resources.

6. That the complexities of technological design involve trade-offs among competing constraints and requirements, including engineering, economic, political, social, and environmental considerations.

7. That technological design is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems.

8. How technological assessment is used to determine the benefits, limitations, and risks associated with existing and proposed technologies.

9. How to utilize a variety of simple and complex technologies.

Essential Questions

Each enduring understanding must be "unpacked" to be meaningful for learning and instruction. Therefore, each enduring understanding has several essential questions associated with it. The essential questions are addressed through the learning cycles.

Bridge Competencies

In addition to focusing on the enduring understandings derived from STL, each Learning Unit helps to address a set of Bridge Competencies developed in conjunction with a consortium of central Illinois community college partners. Representatives from this consortium reviewed each Learning Unit to identify where the Bridge Competencies were being addressed. Each Learning Unit contains a matrix that reflects which Bridge Competencies are addressed in that specific Learning Unit.

Learning Unit Framework

Each Learning Unit developed by Project ProBase follows a similar format in an effort to be consistent and true to a constructivist-based curriculum.

Preliminary Challenge

Students will be introduced to the Learning Unit through a hands-on activity designed to pique their interest and begin to establish a focus for the Learning Unit.

Primary Challenge

Next, the students are introduced to a robust *Primary Challenge,* which is far too complex to be solved at this point in the unit. Students will be asked to reflect on the knowledge and skills needed to reach a plausible solution to this challenge. This instructor-led discussion happens just before the students are led through a series of four-phase learning cycles designed to develop the knowledge and skills necessary to successfully complete the *Primary Challenge*. Time is provided throughout the nine-week Learning Unit to actually work on a solution to the *Primary Challenge*.

Four-phase Learning Cycles

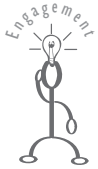
In order to develop plausible solutions for the *Primary Challenge*, students must gain accurate knowledge and appropriate skills throughout each Learning Unit. The learning experiences found in the Project ProBase curriculum are developed using a four-phase learning cycle.

Phase one: Exploration

During this phase of each learning cycle, students will be exploring selected concepts while engaged in hands-on activities. The explorations are done individually as well as in teams. The goal of the *Exploration* phase is to have students construct accurate knowledge about each concept under investigation.

Phase two: Reflection

The *Reflection* phase of the learning cycle offers an opportunity for students to think about what they know about the concepts under investigation. Their reflections are recorded in an Inventor's Logbook that can be used to check their understanding. This phase of the learning cycle also provides an opportunity for the instructor to clear up lingering misconceptions and to be sure that all students are ready to move on.



Phase three: Engagement

The *Engagement* phase of the learning cycle allows the student to apply the knowledge and skills that they are constructing. This phase reinforces their understanding of the important concepts. The activities that students are engaged in are as authentic as possible and are often team activities.

Phase four: Expansion

This phase of the learning cycle is where students can extend their new understandings to new situations. Students should select one of the activities from the several that are suggested. Some of the *Expansion* activities are designed to be done as individuals as homework and some are team activities.

Student and Instructor Roles During Each Phase of the Learning Cycle

Learning Cycle Phase	Student's Role	Instructor's Role
Exploration	• Interacts with materials and equipment • Collects, records, and analyzes data • Designs solutions • Investigates concepts	• Asks questions • Gathers materials • Oversees safety and skills instruction • Encourages Inventor's Logbook entries
Reflection	• Answers questions in Inventor's Logbook • Forms generalizations • Compares team data • Participates in discussions	• Questions students • Leads class discussions • Corrects misconceptions • Facilitates class data sets
Engagement	• Applies concepts, principles, theories • Designs and builds solutions • Solves problems	• Supplies materials • Keeps students on task • Corrects lingering misconceptions • Assures safe practice
Expansion	• Extends concepts to different contexts • Researches • Journalizes in Inventor's Logbook	• Provides appropriate resources • Questions students to ensure connections are made to broader context

Preparing for the Challenge

A goal of the Project ProBase curriculum is to have students work toward the *Primary Challenge* throughout each Learning Unit. Therefore, at the end of each learning cycle students are asked to reflect on the *Primary Challenge*. In many cases the student is provided time to work on the solution to the *Primary Challenge* for a day or two between learning cycles.

Inventor's Logbook

Each Learning Unit developed by Project ProBase makes use of an Inventor's Logbook. An icon like the one above is placed throughout the Learning Unit whenever students are expected to answer specific questions, record data, or write down their observations. The specific requirements for this logbook are left for you to determine.

The Inventor's Logbook entries will also be used to check and assess student progress toward the concepts that each learning cycle is focused on. The rubrics provided at the end of each learning cycle contain an Inventor's Logbook element where the specific concepts are identified. This will encourage your students to make regular entries in their student text and provide dynamic documentation of their progress.

Student Assessment

Student assessment is an important component in the ProBase curriculum. The Instructor's Guide provides several optional rubrics to use for formative and summative student evaluation. The Inventor's Logbook is designed to be a formative assessment of student progress. The Instructor's Guide contains a rubric for assessing each student's Inventor's Logbook. In addition, each *Primary Challenge* has a rubric for summative evaluation.

The *Engagement* phase of each learning cycle affords a unique opportunity to assess student progress. Therefore, a rubric unique to the *Engagement* phase is provided as often as possible.

Rubrics have been inserted in the Instructor's Guide and Student's Guide for assessing a student's contribution to teamwork and daily engagement/preparation.

Materials and Equipment

The Project ProBase curriculum is designed to be taught in a general technology laboratory facility. Each learning cycle details the equipment and materials needed for that specific activity. Each Learning Unit also includes a compiled list of all the equipment and materials needed for the unit in the front of the Instructor's Guide. By design and as much as possible, the equipment and materials used for the activities are easy to find, over-the-counter materials. Where appropriate and necessary, specific vendors have been identified and their contact information has been provided.

Learning Cycle Two:
1e. What are the fundamental processes/ principles used to develop new technologies?

Learning Cycles Three & Five:
4a. What are the systems and subsystems involved in the various contexts of technology?

Learning Cycles Two, Three, Four, & Five:
7c. What design criteria are typically considered when developing new technologies (e.g., marketability, safety, useability, reliability, cost, materials, etc.) and how do these influence the final product/system design?

Learning Cycle Five:
7d. How are decisions made regarding information that should be discarded or ignored?

Learning Cycles One & Three:
7e. How can the attributes of design and the principles of design aid in the development of quality solutions?

Learning Cycles One & Four:
9d. How is technological instrumentation used to measure, calculate, manipulate, and predict the actions of technological devices and systems?

Construction Technologies Overview

Up to this point, we have been discussing the Project ProBase Learning Units in general terms. The following points will be specific to *Construction Technologies*.

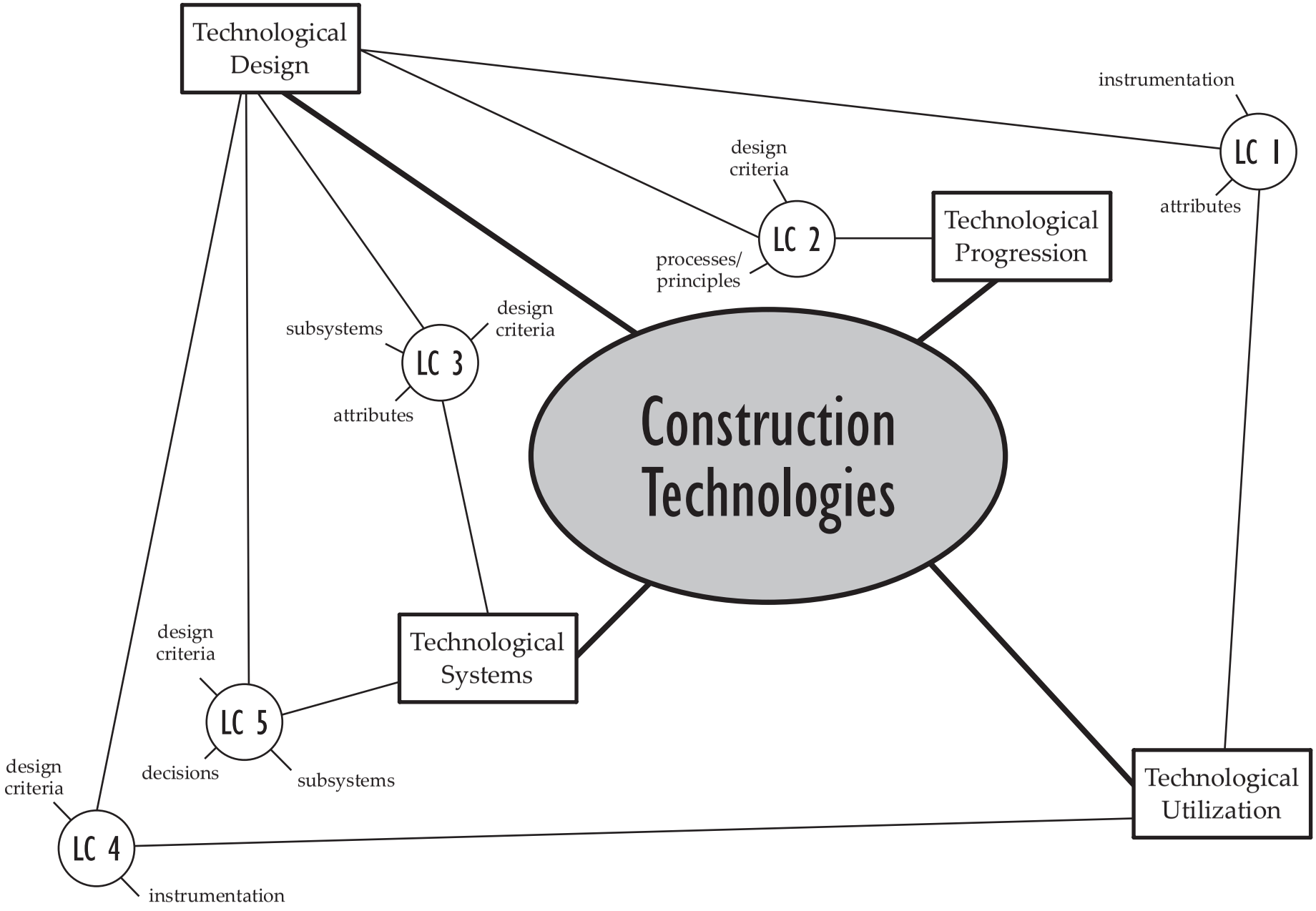
Enduring Understandings and Essential Questions

The *Construction Technologies* Learning Unit focuses on three of the nine enduring understandings. As they complete *Construction Technologies*, students will understand:

1. that technological progression is driven by a number of factors, including individual creativity, product and systems innovation, and human wants and needs.
4. how technological systems work, the components of those systems, and how they fit into the larger technological, economic, and social systems.
7. that technological design is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems.
9. how to utilize a variety of simple and complex technologies.

The essential questions addressed in each learning cycle are correlated to the learning cycle objectives.

ConstructionTechnologies Learning Unit Concept Map



Construction Learning Unit Materials List

Learning Unit Consumables (based on a class size of 28 students)

Qty	Item	Learning Cycle	Notes and Recommended Options
200	Large sheets of paper	Preliminary	
	Pencils and erasers	*Preliminary*,1,2	
	2″ polystyrene foam insulation	1	usually pink or blue in color, available at building supply stores
	Acrylic paint, latex paint, or shellac	1	
	Assorted grits of wet/dry sandpaper	1	usually black in color
	Copies of blank sheet with title block	1	(included in the Appendix)
	Different sizes of drawing paper	1	(A, B, C, etc.)
1	Sheet of 4′ x 8′ x ¾″ plywood or particleboard	1	
	White glue or spray glue	1	
	8 ½″ x 11″ white paper	2	
	Color markers (optional)	2	
	Graph paper	2	
	Tracing paper	2	optional, roll of 24″ x 150′ recommended
	Masking tape and transparent tape	2,3	
25 ft	Vinyl tubing to fit the pump outlet	3	
	Miscellaneous cardboard	3	
	Other miscellaneous building items as desired	3	
	Plastic containers	3	

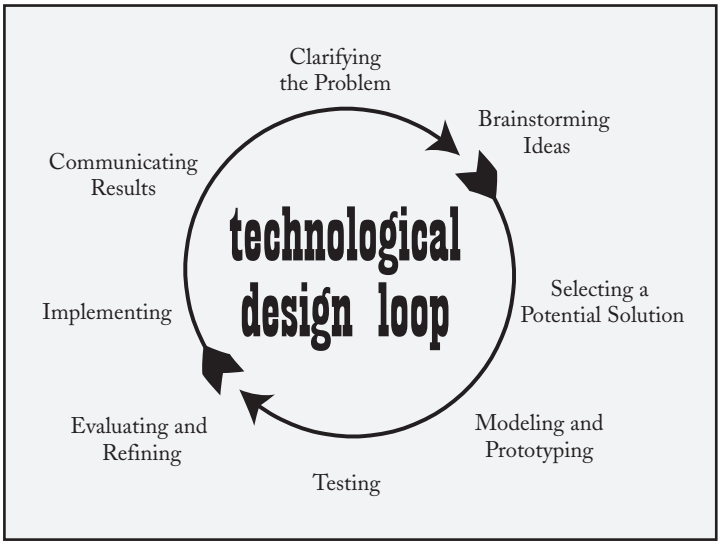
Learning Unit Consumables cont'd			
Qty	**Item**	**Learning Cycle**	**Notes and Recommended Options**
4	½″ Copper elbow	4	
10 ft	½″ Copper tubing, type M	4	
10	½″ Pipe fasteners	4	
2	½″ Water stop, solder fitting	4	
5 lb	10d nails	4	
1 box	14-2 Cable clips	4	
25 ft.	14-2 NM electrical cable	4	
1	1-gang Electrical box	4	
1	1x6 fascia (4′+ long)	4	
1	50 lb Mortar	4	
3	8″ Anchor bolts	4	
1	Duplex electrical outlet	4	
8 oz.	Flux	4	
20	Full concrete blocks	4	
4 ft.	Metal soffit	4	
	Protective floor covering	4	
20 ft^2	Roofing felt	4	
20 ft^2	Shingles (1 pkg)	4	
1 lb	Solder	4	
5 lb	16d nails	4,5	
10	2x10 (8′ long)	4,5	
6	2x12 (8′ long)	4,5	
26	2x4 (8′ long)	4,5	
3	2x4 (8′ long), pressure treated	4,5	
2	4x8 ½″ OSB or plywood	4,5	
3	4x8 ¾″ OSB or plywood	4,5	
5 lb	10 d nails	5	

Learning Unit Equipment (based on a class size of 28 students)			
Qty	**Item**	**Learning Cycle**	**Notes and Recommended Options**
7	Architect's scales	1	
	Assorted hand saws, utility knives, and files	1	
7	Engineer's scales	1	
7	Straight edges or rulers	1	
	City or county map	2	
	Computers and printers	2	
	Digital camera	2	optional
	Local building codes	2	
	Glue guns and glue	3	
1	Stop watch	3	
1	Submersible or aquarium pump	3	
	Hoe/shovel	4	

Learning Unit Equipment cont'd			
Qty	**Item**	**Learning Cycle**	**Notes and Recommended Options**
	Hose-outside access	4	
	Metal hand shears	4	
	Mixing bucket	4	
3	Mortar trowels	4	
	Propane torch	4	
	Wheel barrows	4	
	Circular saw	4 and 5	
4	Crosscut saws	4 and 5	
	Electric drill with ½″ bit and 1″ bit	4 and 5	
8	Hammers	4 and 5	
4	Quick squares	4 and 5	
	Rafter square	4 and 5	
8	Tape measures	4 and 5	

the Technological Design Loop

As a constructivist, problem-based curriculum, the ProBase Learning Units offer a variety of opportunities for students to engage in design activities. The ProBase Learning Units have been developed for upper high school technology education students. It is assumed that students engaging in the ProBase curriculum possess some prerequisite knowledge and skills regarding engineering design. If students do not have previous experience in this area, it may be necessary to provide a brief introduction to design-based problem solving. It is suggested that you use the following design model adapted for the ProBase curriculum from *Standards for Technological Literacy* (International Technology Education Association, 2000/2002).



If you see a need to introduce the design-based problem solving process, it is suggested that you do so in a constructivist manner using a simple design problem. For example, you might have your students use the model presented above as they design a cover for a book or CD. You should attempt to use media beyond paper and pencil such as modeling clay, Styrofoam™, Balsa wood, or cardboard. Other simple design ideas include designing paper airplanes, a package for their favorite snack, a marketing flyer for a new product, an ergonomic handle for a shaving razor, or prototype cardboard seat or a model of other furniture pieces.

Construction Technologies Unit Calendar

Week	Day 1	Day 2	Day 3	Day 4	Day 5
1	Course Introduction; Preliminary Challenge	Preliminary Challenge	Introduction to the Primary Challenge	Learning Cycle 1- *Exploration*	Learning Cycle 1- *Exploration*
2	Learning Cycle 1- *Reflection*	Learning Cycle 1- *Engagement*	Learning Cycle 1- *Engagement*	Preparing for the Primary Challenge	Preparing for the Primary Challenge
3	Learning Cycle 2- *Exploration*	Learning Cycle 2- *Exploration*	Learning Cycle 2- *Reflection* *Engagement*	Learning Cycle 2- *Engagement* *Preparing for the Challenge*	Learning Cycle 3- *Exploration I*
4	Learning Cycle 3- *Exploration I* *Reflection I*	Learning Cycle 3- *Exploration II*	Learning Cycle 3- *Exploration II* *Reflection II*	Learning Cycle 1- *Engagement*	Learning Cycle 3- *Engagement* *Preparing for the Challenge*
5	Learning Cycle 4- *Exploration*	Learning Cycle 4- *Exploration*	Learning Cycle 4- *Reflection* *Engagement*	Learning Cycle 4- *Engagement*	Learning Cycle 4- *Engagement*
6	Learning Cycle 4- *Engagement*	Learning Cycle 4- *Engagement*	Learning Cycle 4- *Engagement*	Learning Cycle 4- *Engagement*	Preparing for the Primary Challenge
7	Learning Cycle 5- *Exploration*	Learning Cycle 5- *Exploration*	Learning Cycle 5- *Reflection* *Engagement*	Learning Cycle 5- *Engagement*	Learning Cycle 5- *Engagement*
8	Primary Challenge	Primary Challenge	Primary Challenge	Primary Challenge	Primary Challenge
9	Primary Challenge	Primary Challenge	Primary Challenge	Presentations of the Primary Challenge	Presentations of the Primary Challenge

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Preliminary and Primary Challenges

Home Sweet Home

Introduction

The goal of the *Preliminary Challenge* is to spur students' interest in learning about construction technologies. The challenge is designed to engage students in the upcoming unit as well as bridge previous knowledge and skills with the content that will be discussed in the upcoming weeks.

Key Concepts

Each Learning Unit is designed to facilitate several enduring understandings. The key concepts have been synthesized from the enduring understandings and essential questions and will focus the learning cycles in the Learning Unit. Each learning cycle is keyed to one or more of the following enduring understandings:

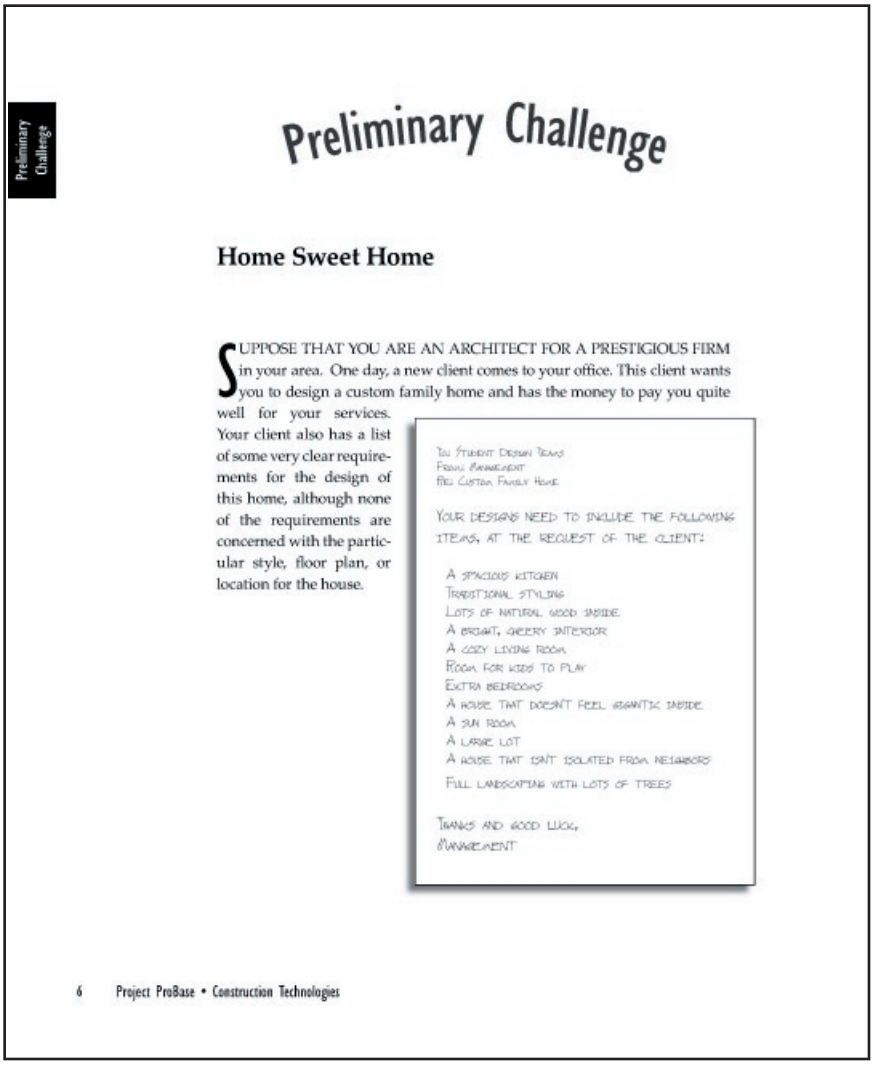
Students will understand:

1. what social, cultural, and political **pressures** lead to the need or want for new technologies.

5. what **resources** are needed to solve a specific design problem.

6. what the key **factors** are that cause designers to make decisions about trade-offs, limitations, and constraints when designing new products and systems.

7. what **design criteria** are typically considered when developing new technologies and how these influence the final product/system design.



Preliminary Challenge

Preliminary Challenge

Home Sweet Home

SUPPOSE THAT YOU ARE AN ARCHITECT FOR A PRESTIGIOUS FIRM in your area. One day, a new client comes to your office. This client wants you to design a custom family home and has the money to pay you quite well for your services. Your client also has a list of some very clear requirements for the design of this home, although none of the requirements are concerned with the particular style, floor plan, or location for the house.

To: Student Design Teams
From: Management
Re: Custom Family Home

Your designs need to include the following items, at the request of the client:

A spacious kitchen
Traditional styling
Lots of natural wood inside
A bright, cheery interior
A cozy living room
Room for kids to play
Extra bedrooms
A house that doesn't feel gigantic inside
A sun room
A large lot
A house that isn't isolated from neighbors
Full landscaping with lots of trees

Thanks and good luck,
Management

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Preliminary Challenge

The *Preliminary Challenge* asks students to individually design a house to meet certain criteria provided by a hypothetical client. The criteria are listed in the Student Guide, and are intentionally broad and somewhat contradictory. The goal of this activity is for students to experience the challenge faced by architects and builders who have to navigate through many conflicting needs and desires as they design and build structures.

Preliminary Challenge

Just before leaving, your client mentions that the home must be completed and ready to live in no later than four months from now. You are on a very tight schedule! You will need to have some preliminary design sketches ready to show your client in two days.

Working individually, sketch a design for your client. You should have at least one sketch that shows a view of the overall house and lot. You should also have four to six sketches that show different areas of the house or lot in greater detail. If you choose, you may draw more than one overall design. While accuracy is not important in sketching, take time to make neat, high-quality sketches. Present your favorite design to the class.

Home Sweet Home 7

Students are asked to sketch at least one view of the overall house and lot and provide four to six sketches that show different areas of the house or lot in greater detail. These sketches do not have to be accurate or well-proportioned, but the word "sketch" is sometimes misconstrued. Students should be encouraged to take time on their sketches, focusing on neatness and quality.

After completion of the sketches, students should present them to the class. This would be an appropriate time to discuss the Reflection questions in the student guide. Discussion notes are included in the *Reflection* section.

Learning Unit Goal

The Learning Unit goal provides a target for the Construction Learning Unit. As students complete this unit, they will be able to understand :

Construction technology involves the design of structures to meet various requirements, and the development of plans for how those buildings can fit into the surrounding community environment.

Teaching Tips

It is suggested that you present this goal to the students before they begin working on the Preliminary Challenge. They are not expected to understand all of it at this point, but they need to become familiar with it.

This goal will be used consistently throughout this Learning Unit. You may want to post this goal in a visible location for easy reference.

Facility Requirements

This activity can be conducted in any environment, as long as students can gather throughout the room in small teams.

Equipment and Materials

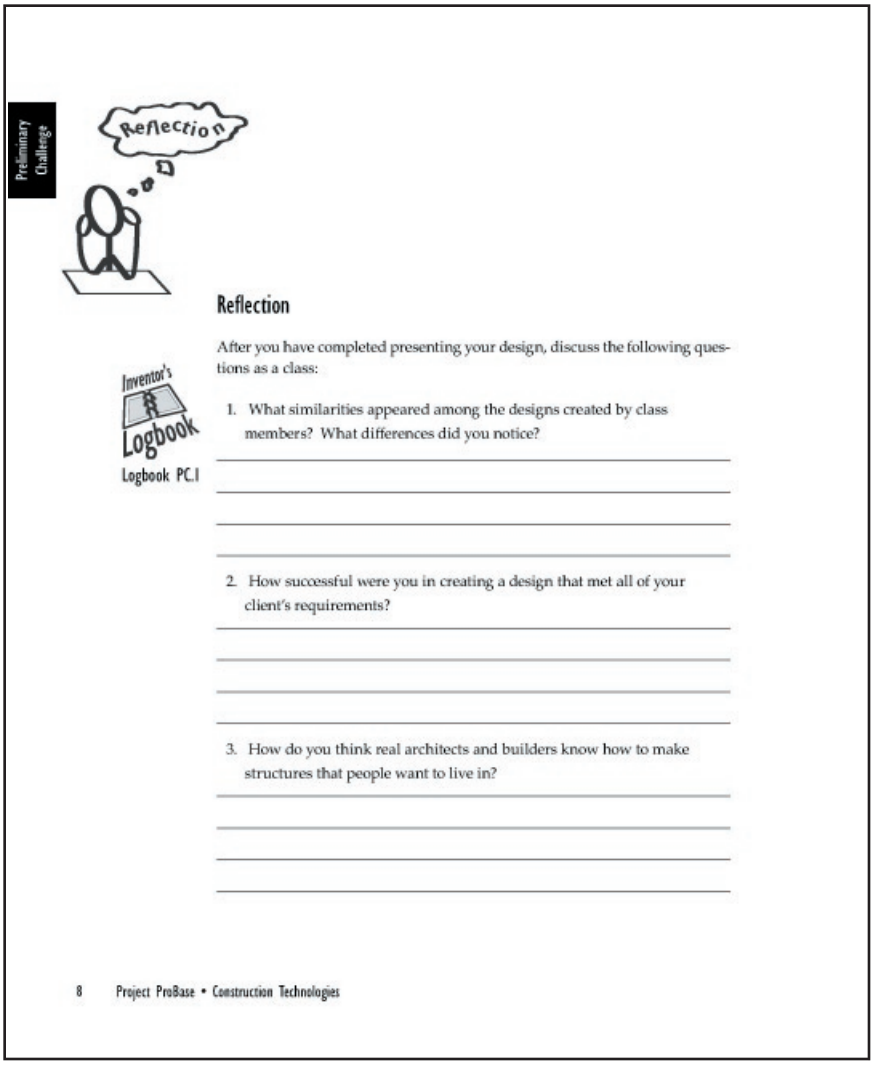
Based on a class of 28 students:

200 large sheets of paper
Pencils
Erasers

Suggested Daily Outline

Day One	Day Two
Introduction, Sketching	Sketching Presentation
Day Three	
Discussion, Intro to *Primary Challenge*	

Estimated Number of 50-minute class periods: **3**



Preliminary Challenge

Reflection

Inventor's Logbook

Logbook PC.1

Reflection

After you have completed presenting your design, discuss the following questions as a class:

1. What similarities appeared among the designs created by class members? What differences did you notice?

2. How successful were you in creating a design that met all of your client's requirements?

3. How do you think real architects and builders know how to make structures that people want to live in?

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Reflection

1. What similarities appeared among the designs created by class members? What differences did you notice?
   Answers will vary. Students should note patterns that were common across different designs. For example, many students will include a foyer or formal dining room into their design, even though such items were not part of the requirements and are seldom used in modern homes. Students may benefit from a discussion of the assumptions we make about "normal" features of a home.

Preliminary Challenge

Introduction to the Unit

Humans have been constructing places to live for thousands of years. Despite our experience, building appropriate structures is still a challenging art and science. People have different needs for living spaces, and those needs often conflict. Despite our desires, a house can't be roomy, cozy, elegant, inexpensive, secluded, and close to neighbors all at the same time.

This unit will show you some of the ways that architects and builders design and build structures to meet people's living needs as well as possible. You will learn about some of the specific skills used in construction, such as scale drawing or framing. You will also learn about some of the big concepts in residential construction, including floor plan layout, infrastructure, and urban planning. This is a lot to cover in one unit, but it has a practical application in your life every day. Let's get started!

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2. How successful were you in creating a design that met all of your client's requirements?
   Ask students which requirements were hardest to meet. Since some of the requirements were (intentionally) contradictory, it would take a skilled designer to accommodate all of them. However, this is true in real life as well. People often hold overlapping and conflicting desires about what they want in a living space. This makes the designer's job much tougher!

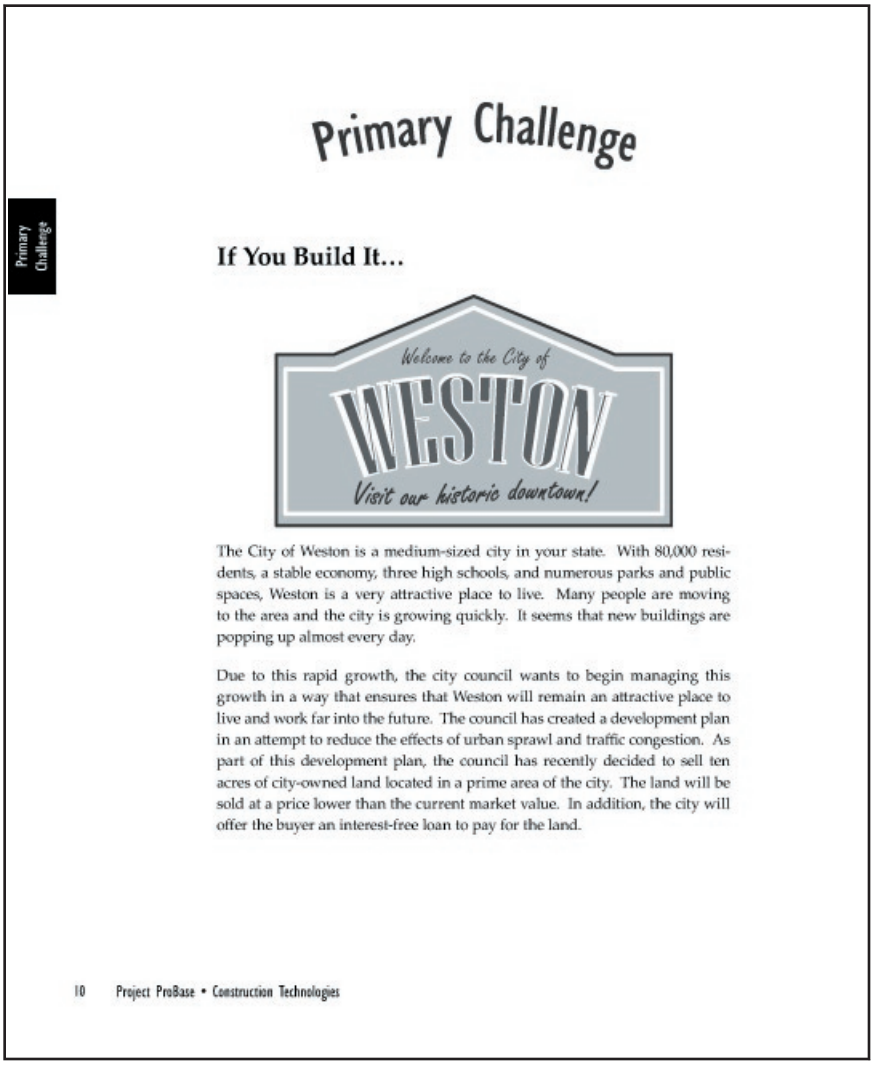
3. How do you think real architects and builders know how to make structures that people want to live in?
   Answers will again very. Students may know professionals in the construction field and have stories to share. If time allows, the class might discuss higher education options, on-the-job experience, etc.

If You Build It…

Introduction

The *Primary Challenge* should be introduced immediately after students complete the *Preliminary Challenge* so that they can begin to relate the concepts developed through the learning cycles to this challenge. You should address any questions about the *Primary Challenge* at this time. Approximately three weeks have been built into the schedule throughout this Learning Unit for students to work on their solution to the *Primary Challenge*. Students will be asked to reflect on this challenge as part of each learning cycle in a section titled *Preparing for the Challenge*.

Estimated Number of 50-minute class periods: **13**



Primary Challenge

Primary Challenge

If You Build It…

The City of Weston is a medium-sized city in your state. With 80,000 residents, a stable economy, three high schools, and numerous parks and public spaces, Weston is a very attractive place to live. Many people are moving to the area and the city is growing quickly. It seems that new buildings are popping up almost every day.

Due to this rapid growth, the city council wants to begin managing this growth in a way that ensures that Weston will remain an attractive place to live and work far into the future. The council has created a development plan in an attempt to reduce the effects of urban sprawl and traffic congestion. As part of this development plan, the council has recently decided to sell ten acres of city-owned land located in a prime area of the city. The land will be sold at a price lower than the current market value. In addition, the city will offer the buyer an interest-free loan to pay for the land.

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Equipment and Materials

All items needed for the *Primary Challenge* are first used in one of the learning cycles. Detailed information is given in each learning cycle. In general, students will need access to large sheets of paper for planning and tools and supplies for modeling.

Why would the city give someone such a great deal on a prime building site? The catch is that the buyer must agree to develop the site as a model *planned unit development* with certain requirements. A planned unit development is a special type of construction project that is developed all at once. Some of the rules that normally cover new construction are ignored. This allows the builder to have a lot of flexibility in how the development is designed. The city wants this development to be a model for other developments in the area. The city particularly wants the development to show off creative, mixed-use areas, green construction, compliance with the Americans with Disabilities Act (ADA), Crime Prevention through Environmental Design (CPTED), and interactive housing or smart house concepts.

The city is now accepting proposals to develop the site. The city council will review all of the proposals and choose one to accept for development. This is a great opportunity. The group that receives the contract will get to develop a profitable building site. At the same time, the project will improve the overall character of the City of Weston.

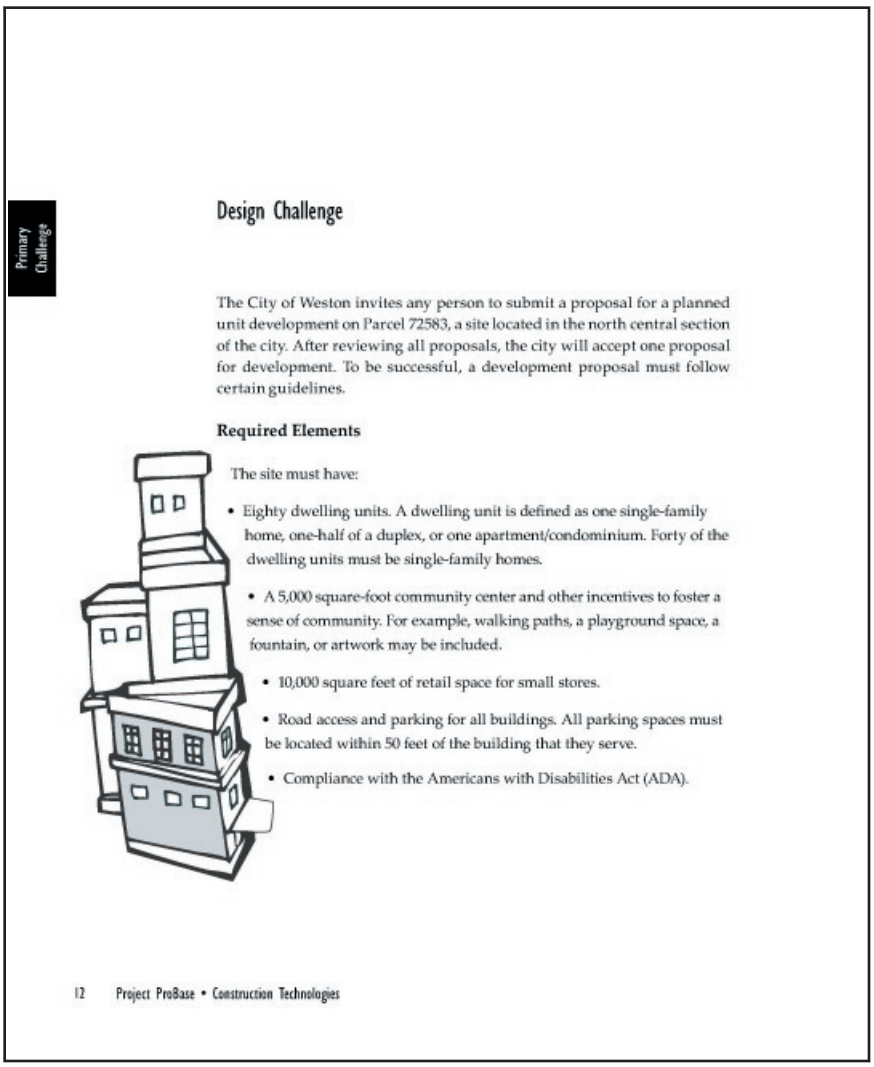
Your challenge, as a class, is to prepare a proposal for the city council. Please take some time to review the aerial photograph and the Proposal Guidelines prepared by the city. The deadline for the completed proposal is sixty calendar days from today.

Notes:

Primary Challenge

Preparing for the Primary Challenge

The *Primary Challenge* is intended to be a large-scale, ongoing project that gives students the opportunity to apply many of the concepts addressed in the learning cycles. In fact, application of these concepts is necessary for successful completion of the *Primary Challenge*. In this unit, students are challenged to design, draw, model, and present a detailed proposal for a planned unit development. A planned unit development is an urban space that is designed as a cohesive unit. Since relationships to other structures are part of the plan, cities typically waive some of the specific building codes that normally regulate lot size and structure placement. This allows greater design flexibility.



Primary Challenge

Design Challenge

The City of Weston invites any person to submit a proposal for a planned unit development on Parcel 72583, a site located in the north central section of the city. After reviewing all proposals, the city will accept one proposal for development. To be successful, a development proposal must follow certain guidelines.

Required Elements

The site must have:

- Eighty dwelling units. A dwelling unit is defined as one single-family home, one-half of a duplex, or one apartment/condominium. Forty of the dwelling units must be single-family homes.
- A 5,000 square-foot community center and other incentives to foster a sense of community. For example, walking paths, a playground space, a fountain, or artwork may be included.
- 10,000 square feet of retail space for small stores.
- Road access and parking for all buildings. All parking spaces must be located within 50 feet of the building that they serve.
- Compliance with the Americans with Disabilities Act (ADA).

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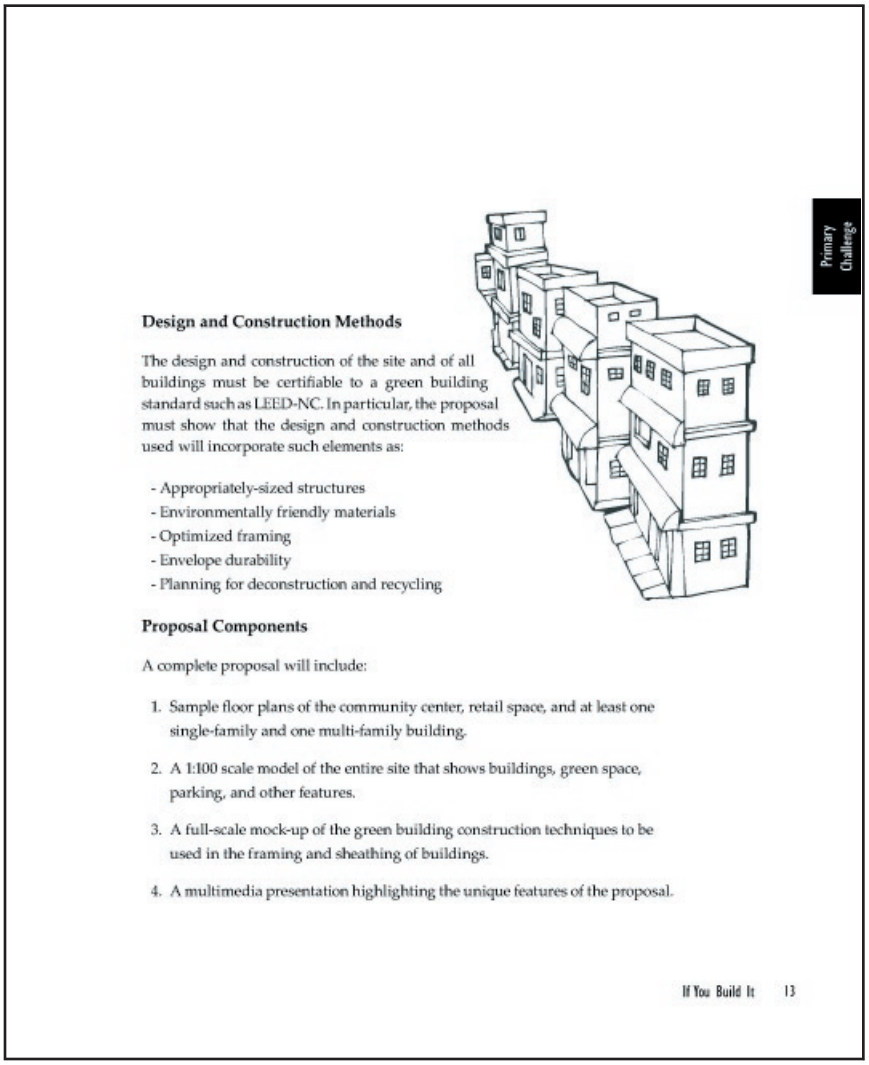
Students will design a planned unit development that includes mixed residential, community, and retail buildings on a site of approximately ten acres. There is an aerial photograph of the site in the student text. To stimulate additional interest, a similar site near the school or somewhere else in the community may be substituted. An ideal site will be ten to fifteen acres, with some natural features that must be worked around. An aerial photo or detailed drawing of the site will be necessary.



Primary Challenge

Design and Construction Methods

The design and construction of the site and of all buildings must be certifiable to a green building standard such as LEED-NC. In particular, the proposal must show that the design and construction methods used will incorporate such elements as:

- Appropriately-sized structures
- Environmentally friendly materials
- Optimized framing
- Envelope durability
- Planning for deconstruction and recycling

Proposal Components

A complete proposal will include:

1. Sample floor plans of the community center, retail space, and at least one single-family and one multi-family building.
2. A 1:100 scale model of the entire site that shows buildings, green space, parking, and other features.
3. A full-scale mock-up of the green building construction techniques to be used in the framing and sheathing of buildings.
4. A multimedia presentation highlighting the unique features of the proposal.

If You Build It 13

There are also specific requirements for the structures that are to be built on the site. One of the main requirements is that structures need to be designed to green building standards. It is possible for the instructor to add certain requirements that are unique to the local situation. For example, structural modifications to resist hurricane or earthquake forces could be addressed. It is recommended that the green building content be left in place and these extra requirements be addressed by the addition of content over several days. Learning Cycle 5 is the most natural place to add this content.

Teaching Tips

The 1:100 scale is suggested but optional. Other scales may be used based on available materials or instructor preferences.

Primary Challenge

At the end of each learning cycle, students will work on one part of the *Primary Challenge*. The task for each learning cycle is shown below:

Learning Cycle 1
Create a scale model of the existing site.

Learning Cycle 2
Design the common space and community elements for the development.

Learning Cycle 3
Design overall land use, including infrastructure.

Learning Cycle 4
Design and model specific building techniques.

Learning Cycle 5
Build full-size examples of framing methods consistent with green building standards.

Even after completion of these tasks, there will still be significant work for students to do in order to complete the *Primary Challenge*. Two weeks are included at the end of the unit to complete other tasks, such as creating drawings, presentation materials, and models needed for the *Primary Challenge*.

Instructor Resources

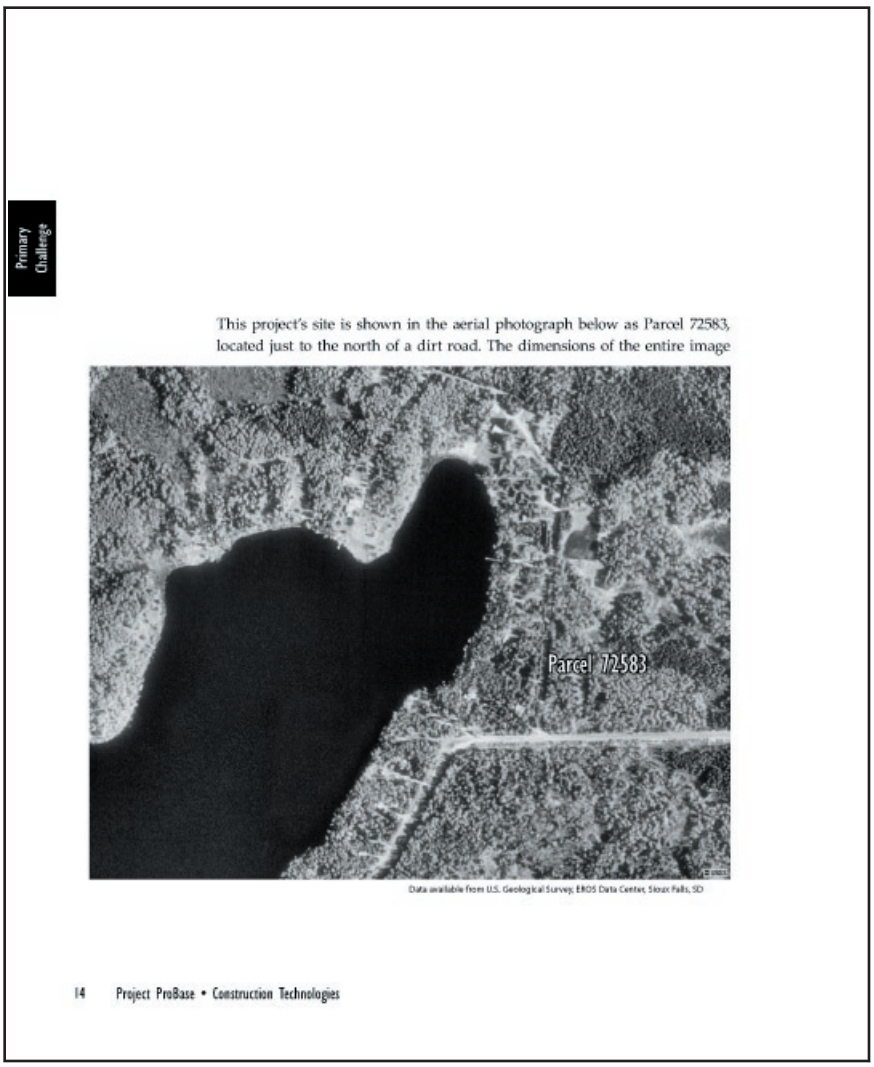
- Aerial photos of much of the United States can be found at http://terraserver.microsoft.com/

- The U.S. Green Building Council is the primary source for material related to green building. The Council's LEED standards are the most commonly accepted green building standards. Their website can be found at http://www.usgbc.org/

- The National Crime Prevention Council has information about how to prevent crime through environmental design at http://www.ncpc.org/ncpc/ncpc?pg=5882-2006-2486

- The National Association of Home Builders offers free software, "Building Homes of our Own," at http://www.nahb.org/generic.aspx?sectionID=184&genericContentID=356

- There are a number of excellent sites on the Internet for construction-framing information. One useful site is the American Wood Council (http://www.awc.org), which publishes the manual *Details of Wood Frame Construction*. The manual is a free download.



Primary Challenge

This project's site is shown in the aerial photograph below as Parcel 72583, located just to the north of a dirt road. The dimensions of the entire image

Data available from U.S. Geological Survey, EROS Data Center, Sioux Falls, SD

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- There are Internet resources to help students with conversion problems including http://www.onlineconversion.com, http://www.convert-me.com, and http://www.efunda.com

- The accessibility guidelines for buildings and facilities, as dictated by the Americans with Disabilities Act, can be located at http://www.access-board.gov/adaag/html/adaag.htm

Teaching tips

In a constructivist-based Learning Unit it is important to focus on conceptual development. Therefore, it will be important for your class to stop and check for understanding from time to time throughout this unit. The students' Inventor's Logbook will serve as one means to check student progress on a regular basis. Here are a few other strategies that may help you keep your students focused on their conceptual development.

- Create a large poster with the key concepts and/or enduring understandings and place it in a prominent spot in your classroom. (An example layout can be found in the appendix.)
- Break students into their *Primary Challenge* teams and identify what they know and what they need to know to solve the *Primary Challenge*. Compile their thoughts through a discussion and create a large class display of what they know and what they need to know. Require the students (or teams) to "check off" the questions that have been answered during the course of the Learning Unit.
- Have your students create concept maps of the unit in their Inventor's Logbook.

Teaching tips

As an option to the parcel of land provided in the Student Guide, you may want to identify an authentic site in your community that would be appropriate for an urban renewal project.

Primary Challenge Rubric

Name: Date:

Element	Criteria				Points
Point Values	40	30	20	10	
Primary Challenge Completion	Followed all specifications and addressed all criteria, parameters, and components set forth in the *Primary Challenge.*	Followed all specifications and met most criteria, parameters, and components set forth in the *Primary Challenge.*	Made a serious attempt to solve the *Primary Challenge,* but did not follow specifications and did not address many of the stated criteria, parameters, or components.	Did not complete specifications and did not meet the stated criteria, parameters, or components.	
				Sub-total	
Point Values	15	10	5	2	
Sketches, Drawings, & Models	Sketches, drawings, and models clearly illustrate an understanding of all requirements, criteria,or specifications, and used proper format.	Sketches, drawings, and models illustrate needed information; addressed most requirements, specifications, or criteria; and used proper format.	Sketches, drawings, and models illustrate some information, but do not address all stated requirements, specifications, or criteria; format problems.	Sketches, drawings, and models do not illustrate all needed information; incomplete or poorly presented; and not in proper format.	
Required Elements and Design Methods	Successfully met all three stated requirements and five design methods.	Team met most of the stated requirements and most of the design methods.	Some of the stated requirements and some of the design methods were met.	Few of the stated requirements were met and few of the design methods were used.	
Proposal Components	Successfully completed sample floor plans, scale model, and mock-up.	Completed most of the sample floor plans, scale model, and mock-up.	All but one of the components was completed or partially completed.	Few of the components were completed or partially completed.	
Presentation	Presentation demonstrates a full grasp of the major concepts, addresses requirements, and conforms to time limit constraints.	Presentation demonstrates significant understanding of major concepts, addresses most presentation requirements, and conforms to time limitations.	Presentation topically addresses some of the concepts delivered in this unit, but does not conform to stated presentation guidelines and/or time limits.	Presentation does not demonstrate a grasp of the major concepts delivered in this unit and/or does not address stated presentation guidelines or time limits.	
				Total Points	

Learning Cycle One

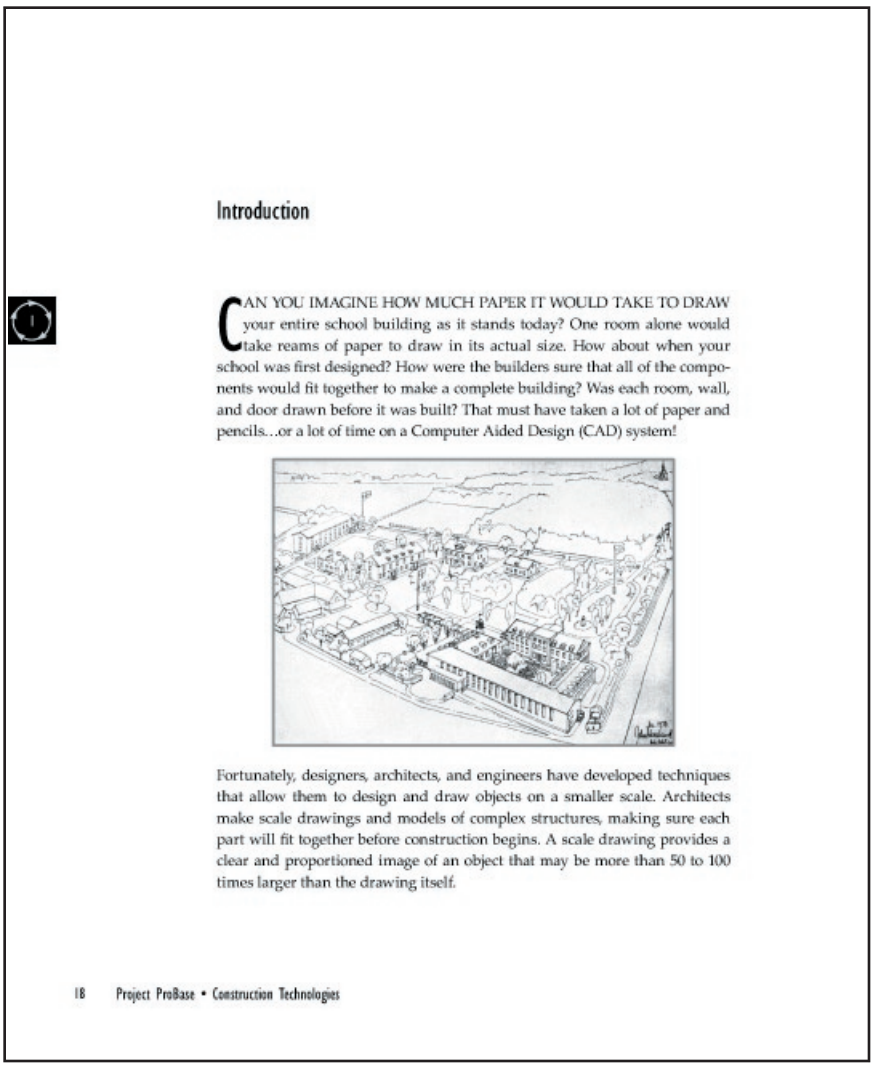
The Incredible Shrinking Design

1

The Incredible Shrinking Design

Introduction

This learning cycle will introduce students to the techniques and tools used in technical drawing and modeling. The *Exploration* introduces students to the concept of scale drawing, including architect's and engineer's scales, measurement, and conversion. Students are asked to create a scale drawing of an object, which you need to provide. The *Engagement* section discusses the design loop as well as scale modeling. Students are asked to design, draw, and model a welcome sign for their planned unit development. The *Preparing for the Challenge* portion asks them to design, draw, and model a site model for their planned unit development. This model will be used in upcoming learning cycles as students continue work on their planned unit development.



Introduction

CAN YOU IMAGINE HOW MUCH PAPER IT WOULD TAKE TO DRAW your entire school building as it stands today? One room alone would take reams of paper to draw in its actual size. How about when your school was first designed? How were the builders sure that all of the components would fit together to make a complete building? Was each room, wall, and door drawn before it was built? That must have taken a lot of paper and pencils…or a lot of time on a Computer Aided Design (CAD) system!

Fortunately, designers, architects, and engineers have developed techniques that allow them to design and draw objects on a smaller scale. Architects make scale drawings and models of complex structures, making sure each part will fit together before construction begins. A scale drawing provides a clear and proportioned image of an object that may be more than 50 to 100 times larger than the drawing itself.

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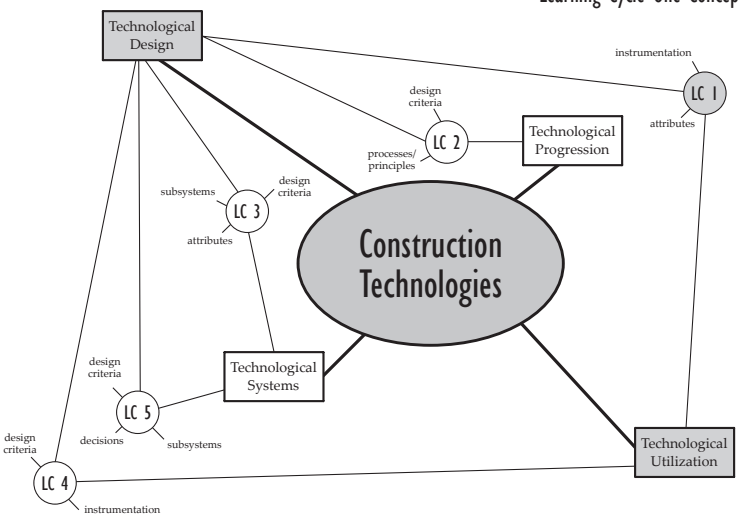
Objectives and Essential Questions

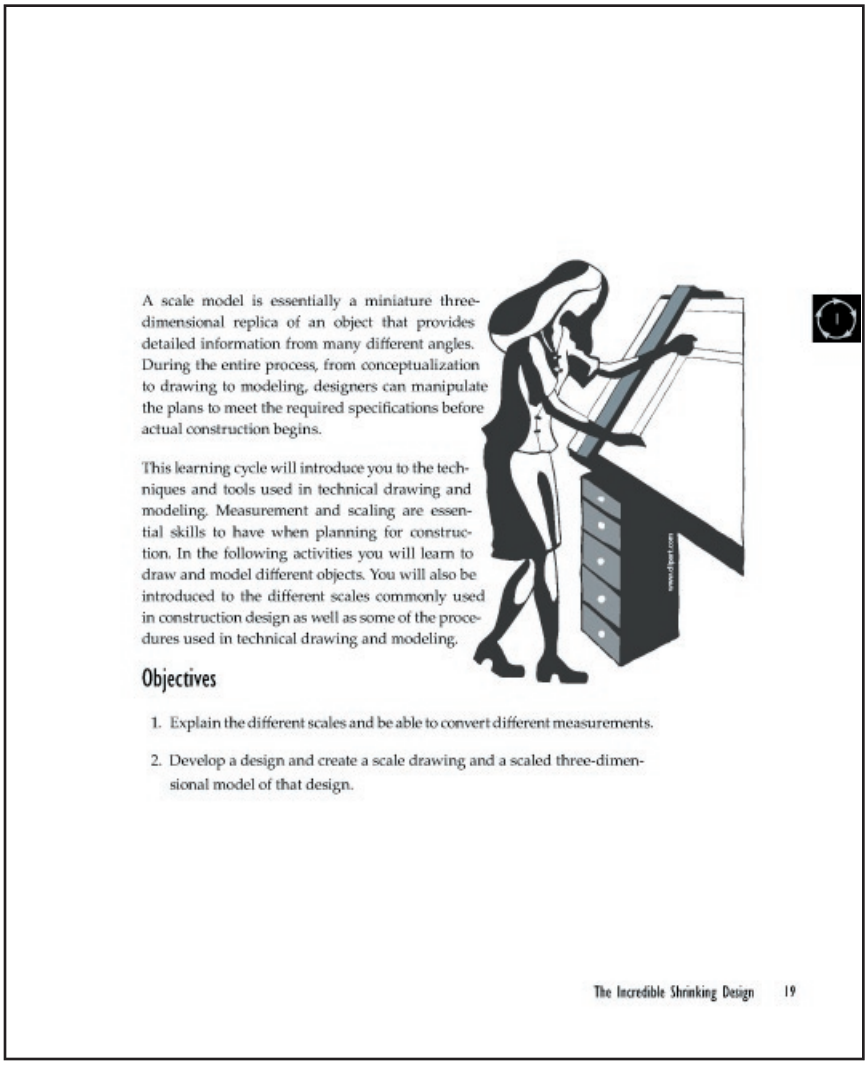
After completeing this learning cycle, students will be able to:

1. Explain the different scales and be able to convert different measurements.

Essential Question 9d: How is technological instrumentation used

ConstructionTechnologies
Learning Cycle One Concept Map





A scale model is essentially a miniature three-dimensional replica of an object that provides detailed information from many different angles. During the entire process, from conceptualization to drawing to modeling, designers can manipulate the plans to meet the required specifications before actual construction begins.

This learning cycle will introduce you to the techniques and tools used in technical drawing and modeling. Measurement and scaling are essential skills to have when planning for construction. In the following activities you will learn to draw and model different objects. You will also be introduced to the different scales commonly used in construction design as well as some of the procedures used in technical drawing and modeling.

Objectives

1. Explain the different scales and be able to convert different measurements.
2. Develop a design and create a scale drawing and a scaled three-dimensional model of that design.

The Incredible Shrinking Design 19

to measure, calculate, manipulate, and predict the actions of technological devices and systems?

2. Develop a design and create a scale drawing and a scale three-dimensional model of that design.

Essential Question 7e: How can the attributes of design and the principles of design aid in the development of quality solutions?

Facility Requirements

Students will need access to large work spaces to measure, draw, and model different objects. They will also need access to computers for research and preparation. If desired, the scale drawing portions of this learning cycle can be completed using CAD software. In that case, each student will need individual access to a computer with CAD software.

Equipment and Materials

Different sizes of drawing paper (A, B, C, etc.)

Copies of blank sheet with title block (included in the Appendix)

Pencils

(7) Architect's scales

(7) Engineer's scales

(7) Straight edges or rulers

2″ thick polystyrene foam insulation (usually pink or blue in color, available at building supply stores)

White glue or spray glue

Assorted grits of wet/dry sandpaper (usually black in color)

Assorted hand saws, utility knives, and files

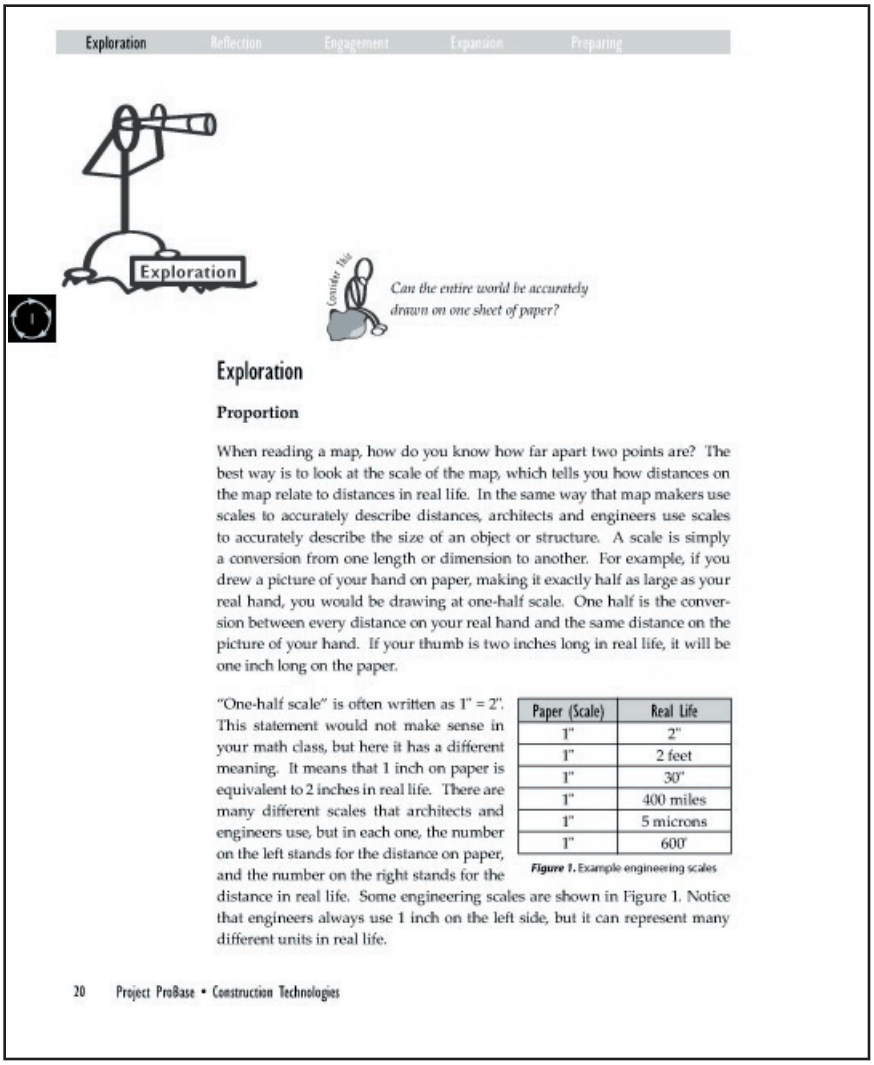
Acrylic paint, latex paint, or shellac

1 sheet of 4′ x 8′ x ¾″ plywood or particleboard

Estimated number of 50-minute class periods: **7**

Suggested Daily Outline

Day One	Day Two
Introduction *Exploration*	*Exploration*
Day Three	**Day Four**
Reflection	*Engagement*
Day Five	**Day Six**
Engagement	Preparing for the Challenge
Day Seven	
Preparing for the Challenge	



Exploration Reflection Engagement Expansion Preparing

Exploration

Consider this

Can the entire world be accurately drawn on one sheet of paper?

Exploration

Proportion

When reading a map, how do you know how far apart two points are? The best way is to look at the scale of the map, which tells you how distances on the map relate to distances in real life. In the same way that map makers use scales to accurately describe distances, architects and engineers use scales to accurately describe the size of an object or structure. A scale is simply a conversion from one length or dimension to another. For example, if you drew a picture of your hand on paper, making it exactly half as large as your real hand, you would be drawing at one-half scale. One half is the conversion between every distance on your real hand and the same distance on the picture of your hand. If your thumb is two inches long in real life, it will be one inch long on the paper.

"One-half scale" is often written as 1" = 2". This statement would not make sense in your math class, but here it has a different meaning. It means that 1 inch on paper is equivalent to 2 inches in real life. There are many different scales that architects and engineers use, but in each one, the number on the left stands for the distance on paper, and the number on the right stands for the distance in real life. Some engineering scales are shown in Figure 1. Notice that engineers always use 1 inch on the left side, but it can represent many different units in real life.

Paper (Scale)	Real Life
1"	2"
1"	2 feet
1"	30'
1"	400 miles
1"	5 microns
1"	600'

Figure 1. Example engineering scales

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Paper (Scale)	Real Life
1"	1'
½"	1'
¼"	1'
3"	1'
⅜"	1'
⅛"	1'

Figure 2. Example architectural scales

Architects use slightly different scales, some of which are shown in Figure 2. Notice that architects always use one foot in real life on the right side, but it is converted to different fractions of inches on the left side. Keep in mind that engineer's scale and architect's scale are very similar. Both use one number on the left to indicate the size on paper, and one number on the right to indicate the size in real life. Which scale is used on any given drawing depends on the actual size of the structure, the size of paper, and the amount of detail to be shown.

Use the architect's scale ¼" = 1' to draw a line representing 24 feet.

Paper (Scale)	Real Life
¼"	1'
??	24'
¼" x 24	1' x 24

To get to 24 feet on the right side, multiply both sides by 24. Remember units!

3"	24'

Drawing a building to scale requires converting many real-life measurements to the right size on paper. Examine the example at left.

Fortunately, engineers and architects have developed tools to make this process easier. The tools are also called scales. Scales make it much easier to go back and forth between the paper and real life. Instead of making numerous math calculations, a scale is used to automatically draw objects to an accurate scale on paper. It is also used to measure a drawing and quickly find the real-life measurement.

Exploration

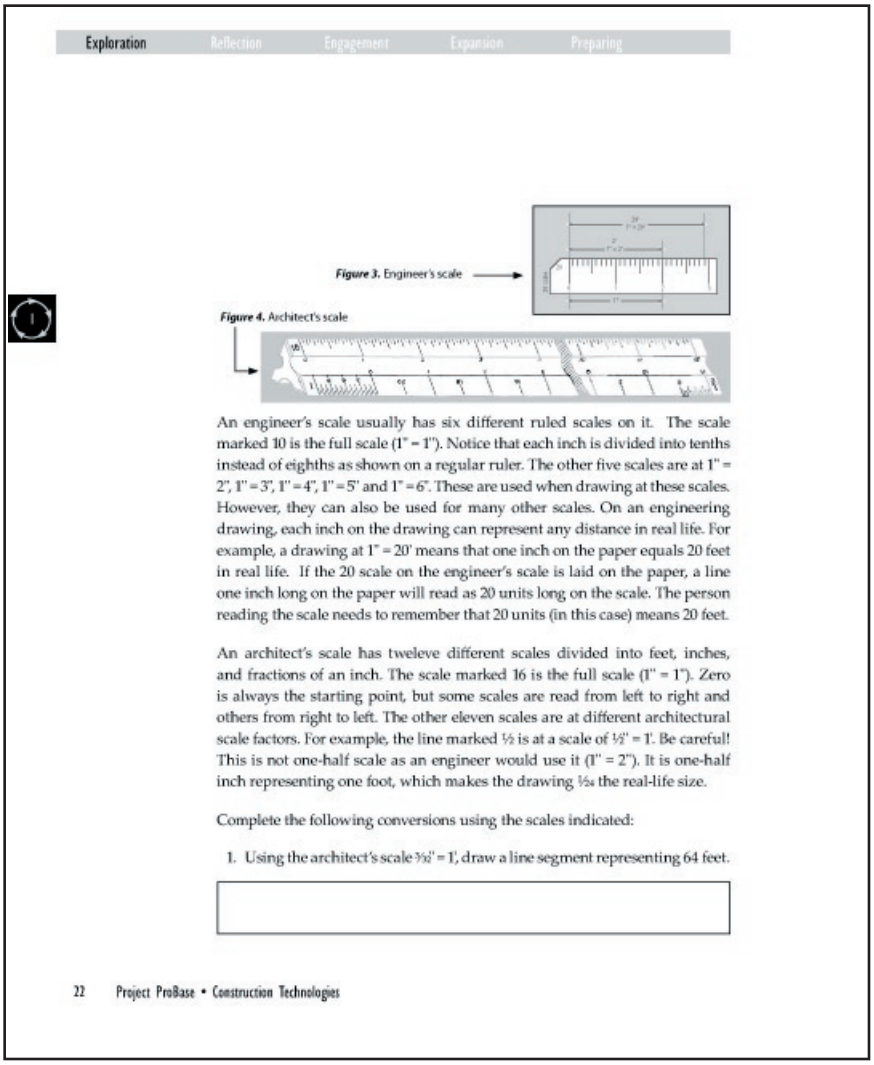
Proportion

The activities in this section are designed to give students an understanding of the different scales used in construction. In addition, students will learn the importance of proportion, measurement, and conversion.

Students are asked to complete the following conversions using the scales indicated below:

1. Using the architect's scale 3/32″ = 1′, draw a line segment to represent 64 feet.

The line drawn should be (64 * 3/32 =) 6 inches long.



Exploration Reflection Engagement Expansion Preparing

Figure 3. Engineer's scale

Figure 4. Architect's scale

An engineer's scale usually has six different ruled scales on it. The scale marked 10 is the full scale (1" = 1"). Notice that each inch is divided into tenths instead of eighths as shown on a regular ruler. The other five scales are at 1" = 2", 1" = 3", 1" = 4", 1" = 5' and 1" = 6". These are used when drawing at these scales. However, they can also be used for many other scales. On an engineering drawing, each inch on the drawing can represent any distance in real life. For example, a drawing at 1" = 20' means that one inch on the paper equals 20 feet in real life. If the 20 scale on the engineer's scale is laid on the paper, a line one inch long on the paper will read as 20 units long on the scale. The person reading the scale needs to remember that 20 units (in this case) means 20 feet.

An architect's scale has tweleve different scales divided into feet, inches, and fractions of an inch. The scale marked 16 is the full scale (1" = 1"). Zero is always the starting point, but some scales are read from left to right and others from right to left. The other eleven scales are at different architectural scale factors. For example, the line marked ½ is at a scale of ½" = 1'. Be careful! This is not one-half scale as an engineer would use it (1" = 2"). It is one-half inch representing one foot, which makes the drawing 1/24 the real-life size.

Complete the following conversions using the scales indicated:

1. Using the architect's scale 3/32" = 1', draw a line segment representing 64 feet.

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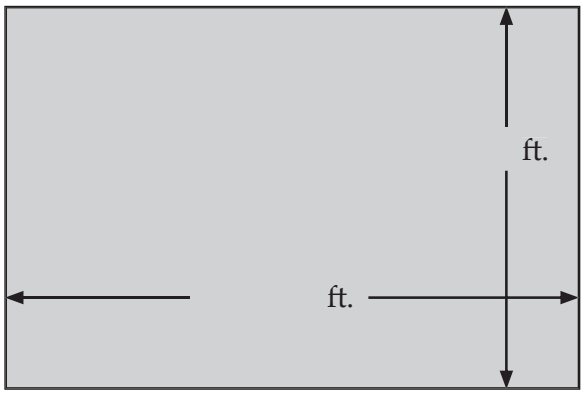
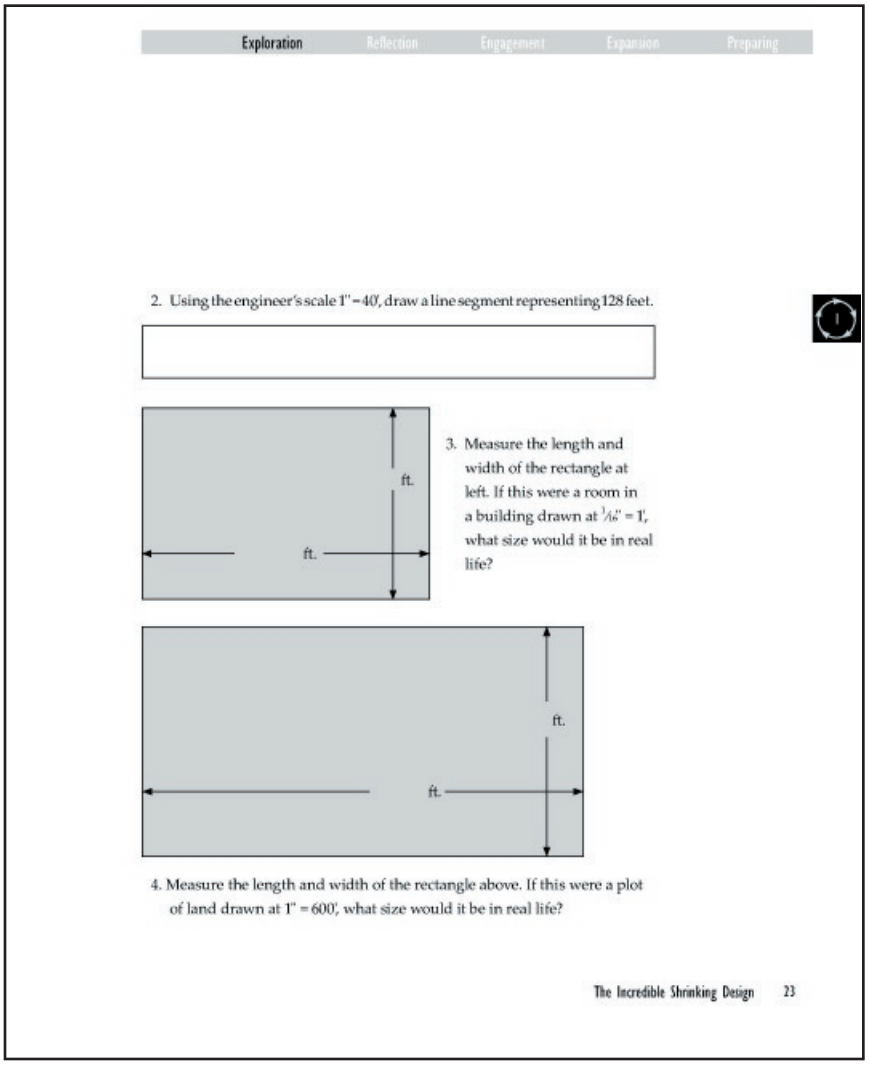




Exploration Reflection Engagement Expansion Preparing

2. Using the engineer's scale 1" = 40', draw a line segment representing 128 feet.

3. Measure the length and width of the rectangle at left. If this were a room in a building drawn at 1/16" = 1', what size would it would be in real life?

4. Measure the length and width of the rectangle above. If this were a plot of land drawn at 1" = 600', what size would it be in real life?

The Incredible Shrinking Design 23

2. Using the engineer's scale 1" = 40', draw a line segment to represent 128 feet.

The line drawn should be (128 / 40 =) 3.2 inches long.

3. Measure the length and width of the rectangle on the previous page. If this were a room in a building drawn at 1/16" = 1', what size would it be in real life?

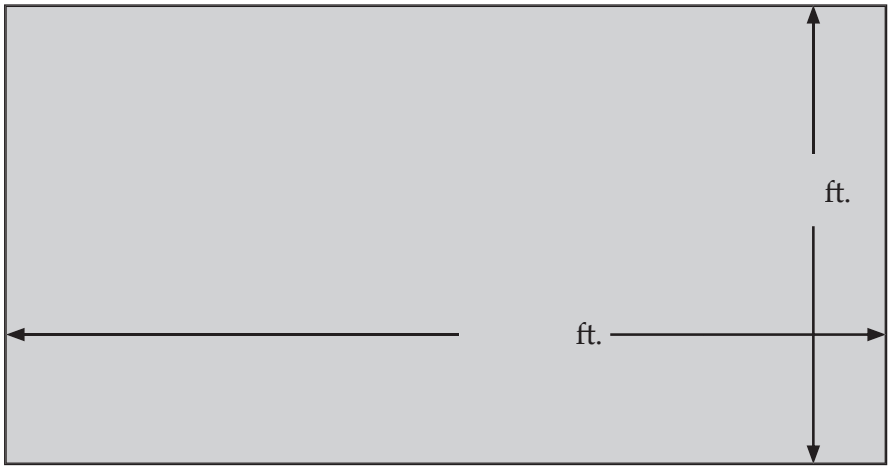
The rectangle is 3 inches long and 2 inches wide.

The actual dimensions would be:
*Length = 3 / 0.0625 = 3 * 16 = 48 ft*
*Width = 2 /0.0625 = 2 * 16 = 32 ft*

4. Measure the length and width of the rectangle below. If this were a plot of land drawn at 1"=600', what size would it be in real life?

The rectangle is 4.6 inches long and 2.4 inches wide.

The dimensions of the actual figure:
*Length = 4.6 * 600 = 2760 feet*
*Width = 2.4 * 600 = 1440 feet*



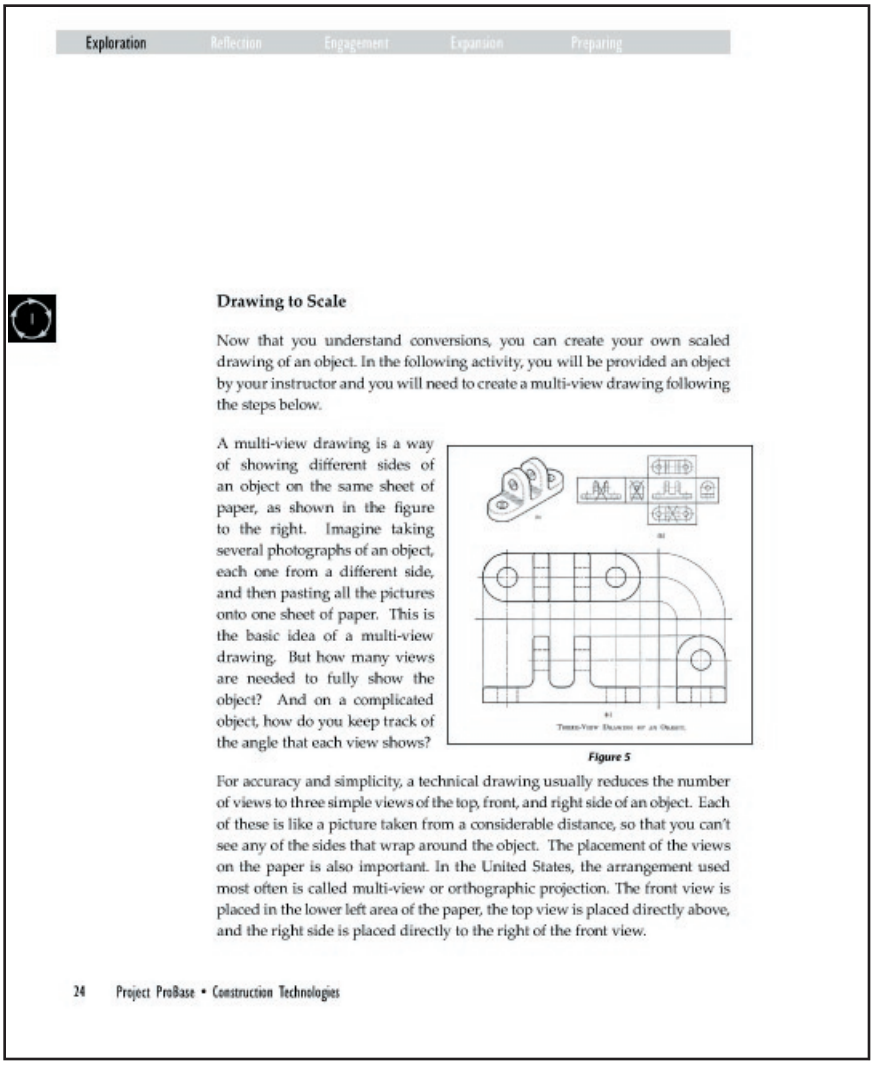
Drawing to Scale

Students are asked to create a multi-view drawing of an object found in the classroom. The object should have straight lines and not be too complex for students with little experience in drawing to scale. Ideally, there should be several identical items, so that several students can make measurements at the same time.

Suggested objects:

Desk
Table
Computer

Students are asked to determine the appropriate scale based on the detail of the object and the size of the paper. There is a blank drawing sheet with title block provided for you to copy in the Appendix of this guide. However, you may decide to provide the students with different sizes of paper so they can choose the scale to fit according to the paper size. You may also choose to have the students create their own title block.



Exploration Reflection Engagement Expansion Preparing

Drawing to Scale

Now that you understand conversions, you can create your own scaled drawing of an object. In the following activity, you will be provided an object by your instructor and you will need to create a multi-view drawing following the steps below.

A multi-view drawing is a way of showing different sides of an object on the same sheet of paper, as shown in the figure to the right. Imagine taking several photographs of an object, each one from a different side, and then pasting all the pictures onto one sheet of paper. This is the basic idea of a multi-view drawing. But how many views are needed to fully show the object? And on a complicated object, how do you keep track of the angle that each view shows?

Figure 5

For accuracy and simplicity, a technical drawing usually reduces the number of views to three simple views of the top, front, and right side of an object. Each of these is like a picture taken from a considerable distance, so that you can't see any of the sides that wrap around the object. The placement of the views on the paper is also important. In the United States, the arrangement used most often is called multi-view or orthographic projection. The front view is placed in the lower left area of the paper, the top view is placed directly above, and the right side is placed directly to the right of the front view.

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Teaching Tips

These activities can be completed using CAD software. You may decide to use this learning cycle as an introduction or refresher for students working with CAD. However, all of the activities were developed and can be completed with paper and a pencil.

Now it is your turn to make a multi-view or orthographic scale drawing of an object in your classroom. Your instructor will provide you with the object and you must determine the appropriate scale to use in order to provide enough detail and still fit your drawing on the piece of paper. Your instructor will provide you with a piece of paper that has a title block included. Follow the steps below to help guide you in making your scale drawing.

1. Measure the object to determine the length, width, and height of the front, top, and right side of the object.
2. Determine the appropriate scale to fit the object on the paper.
   a. Begin at the lower left of the paper and draw very light lines to represent the front view of the object. Do the same for the other two views (the top and right side). If all three views will not fit using this scale, then choose a different scale that will reduce the proportions.
   b. An equal amount of space should also be placed around each of the views and the margins (a minimum of 1.5").
3. Once the appropriate scale is chosen, draw the three views of the object using a straight edge for lines and arcs for curves. (Do not use the scale.)
4. Add details of the object to the drawing.

Neatly complete the Title Block with your name, the name of the object, who it is being drawn for, when it was drawn, and the scale of the drawing.

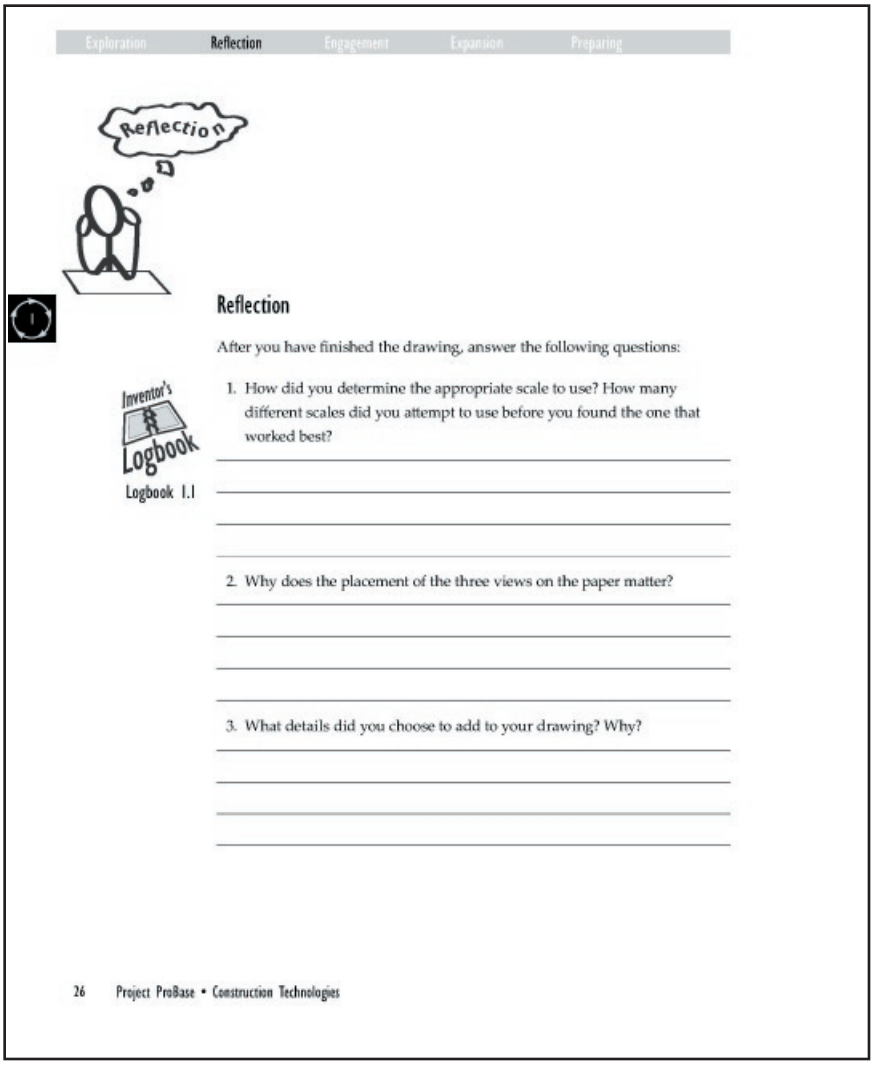
Teaching Tips

You may decide to instruct the students on the "Alphabet of Lines." The Alphabet of Lines is a list of line symbols that are used on technical drawings to represent the shape and describe the size of an object. Lines are drawn at a different thickness or darkness for contrast, as well as to denote the importance of the line. For more information, search for "Alphabet of Lines" online.

Reflection

1. How did you determine the appropriate scale to use? How many different scales did you attempt to use before you found the one that worked best?
   Answers will vary. Some may use trial and error and others may calculate the appropriate scale before they begin to draw.

2. Why does the placement of the three views on the paper matter?
   The placement of the views communicates more information about the object. A person viewing the drawing will know what view they are looking at by the placement. When correctly positioned, the views can be folded to create a three-dimensional cube showing the object.



Exploration Reflection Engagement Expansion Preparing

Reflection

Reflection

After you have finished the drawing, answer the following questions:

Inventor's Logbook

Logbook 1.1

1. How did you determine the appropriate scale to use? How many different scales did you attempt to use before you found the one that worked best?

2. Why does the placement of the three views on the paper matter?

3. What details did you choose to add to your drawing? Why?

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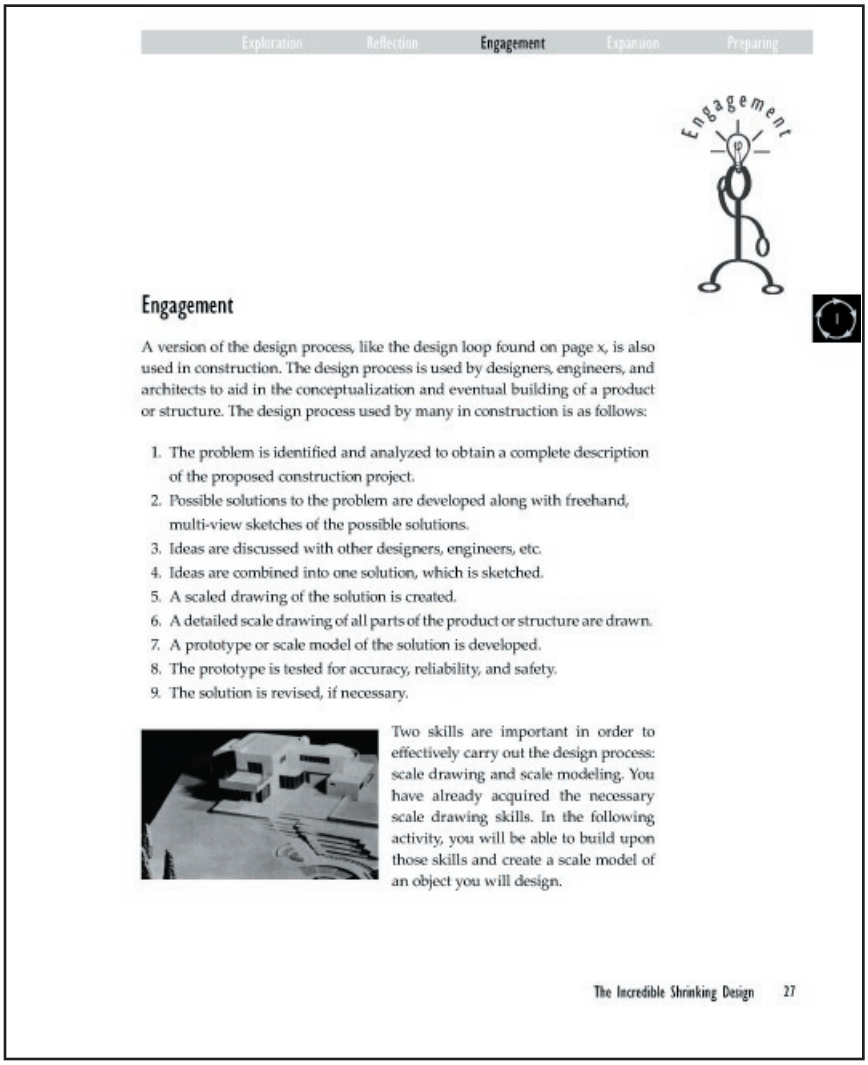
3. What details did you choose to add to your drawing? Why?
   Answers will vary. Details will become more important as students' work becomes more complicated.



Exploration Reflection Engagement Expansion Preparing

Engagement

Engagement

A version of the design process, like the design loop found on page x, is also used in construction. The design process is used by designers, engineers, and architects to aid in the conceptualization and eventual building of a product or structure. The design process used by many in construction is as follows:

1. The problem is identified and analyzed to obtain a complete description of the proposed construction project.
2. Possible solutions to the problem are developed along with freehand, multi-view sketches of the possible solutions.
3. Ideas are discussed with other designers, engineers, etc.
4. Ideas are combined into one solution, which is sketched.
5. A scaled drawing of the solution is created.
6. A detailed scale drawing of all parts of the product or structure are drawn.
7. A prototype or scale model of the solution is developed.
8. The prototype is tested for accuracy, reliability, and safety.
9. The solution is revised, if necessary.

Two skills are important in order to effectively carry out the design process: scale drawing and scale modeling. You have already acquired the necessary scale drawing skills. In the following activity, you will be able to build upon those skills and create a scale model of an object you will design.

The Incredible Shrinking Design 27

Engagement

Students are asked to utilize the skills they have acquired in the *Exploration* to design, draw, and model a welcome sign for their planned unit development. You may need to spend some time discussing the tools and techniques involved in scale modeling. A short discussion of modeling is included in the Student Guide, but students will need considerable guidance with technique.

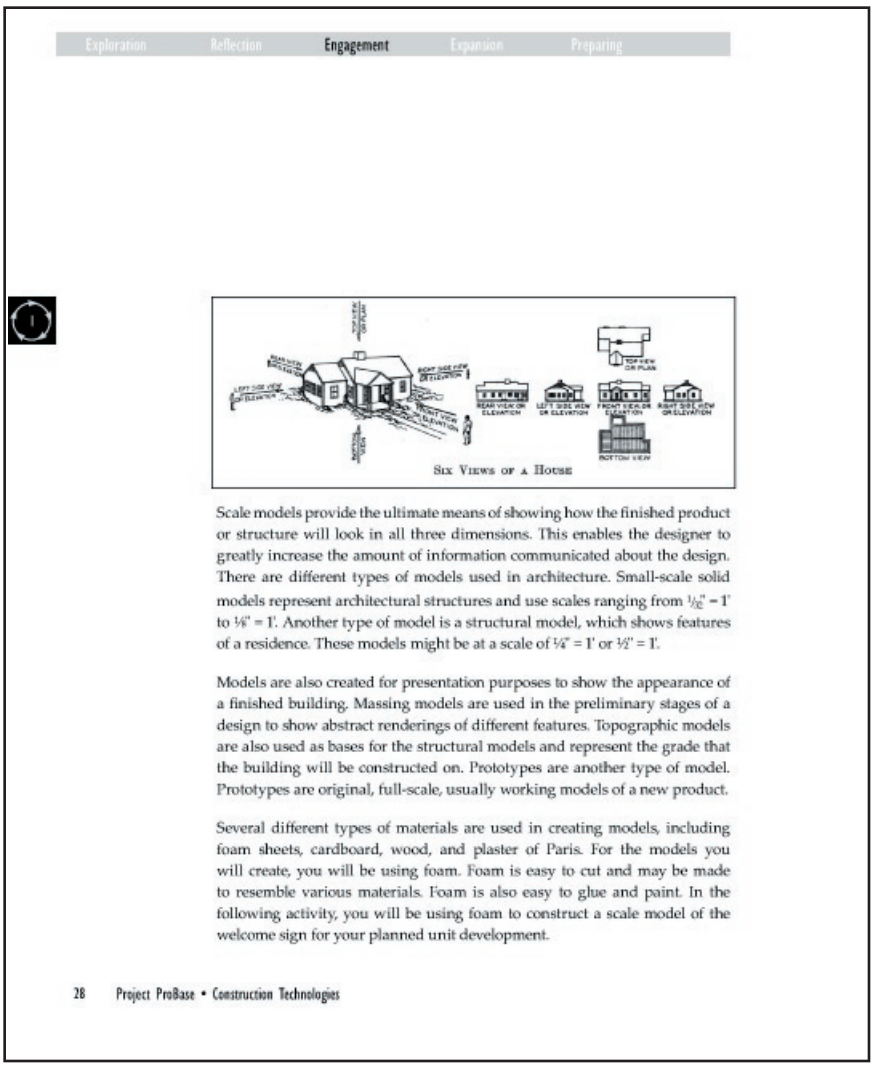
Students should meet with their *Primary Challenge* teams. They will need to first design and then create a multi-view drawing of their sign. Once they have had their design and drawing approved by you they can construct their model according to the requirements listed.

Polystyrene foam insulation is the recommended material for model building in this unit. It has several advantages over other materials--it is easy to cut and sand, it is very inexpensive in terms of cost per volume of material, and it is light-weight. However, it does have disadvantages, too. It breaks and dents easily. Sanding the foam creates a fine dust that is hard to clean up. Care is also needed when painting. Techniques for working with foam are explained on the following pages. If another material is preferred, softwoods or polymer clay are also suitable for this unit. Techniques for these materials are not covered in this guide.

Foam Modeling Technique

The general technique for working with foam is to start with a large block. Mark features to be cut on the faces of the block and then cut and sand to finished shape. Large blocks can be made by gluing smaller sheets together. It is best if the glue is kept away from areas that will later be sanded, since the glue sands differently than the foam.

Polystyrene foam can be easily cut with almost any tool, including serrated kitchen knives. For best results, a very sharp blade should be used. A utility knife with a new blade can create a very fine cut that needs no sanding. Fine-toothed hand saws create a surface that cleans up with some sanding. Power band saws also cut quite well. Circular saws and table saws are not recommended because the heat of the rotating blade can cause the foam to melt and bind against the blade. Hot wire foam cutters are also not recommended for pink or blue polystyrene foam, since the fumes produced by the foam are hazardous.



Exploration Reflection Engagement Expansion Preparing

Six Views of a House

Scale models provide the ultimate means of showing how the finished product or structure will look in all three dimensions. This enables the designer to greatly increase the amount of information communicated about the design. There are different types of models used in architecture. Small-scale solid models represent architectural structures and use scales ranging from 1/32" = 1' to 1/8" = 1'. Another type of model is a structural model, which shows features of a residence. These models might be at a scale of 1/4" = 1' or 1/2" = 1'.

Models are also created for presentation purposes to show the appearance of a finished building. Massing models are used in the preliminary stages of a design to show abstract renderings of different features. Topographic models are also used as bases for the structural models and represent the grade that the building will be constructed on. Prototypes are another type of model. Prototypes are original, full-scale, usually working models of a new product.

Several different types of materials are used in creating models, including foam sheets, cardboard, wood, and plaster of Paris. For the models you will create, you will be using foam. Foam is easy to cut and may be made to resemble various materials. Foam is also easy to glue and paint. In the following activity, you will be using foam to construct a scale model of the welcome sign for your planned unit development.

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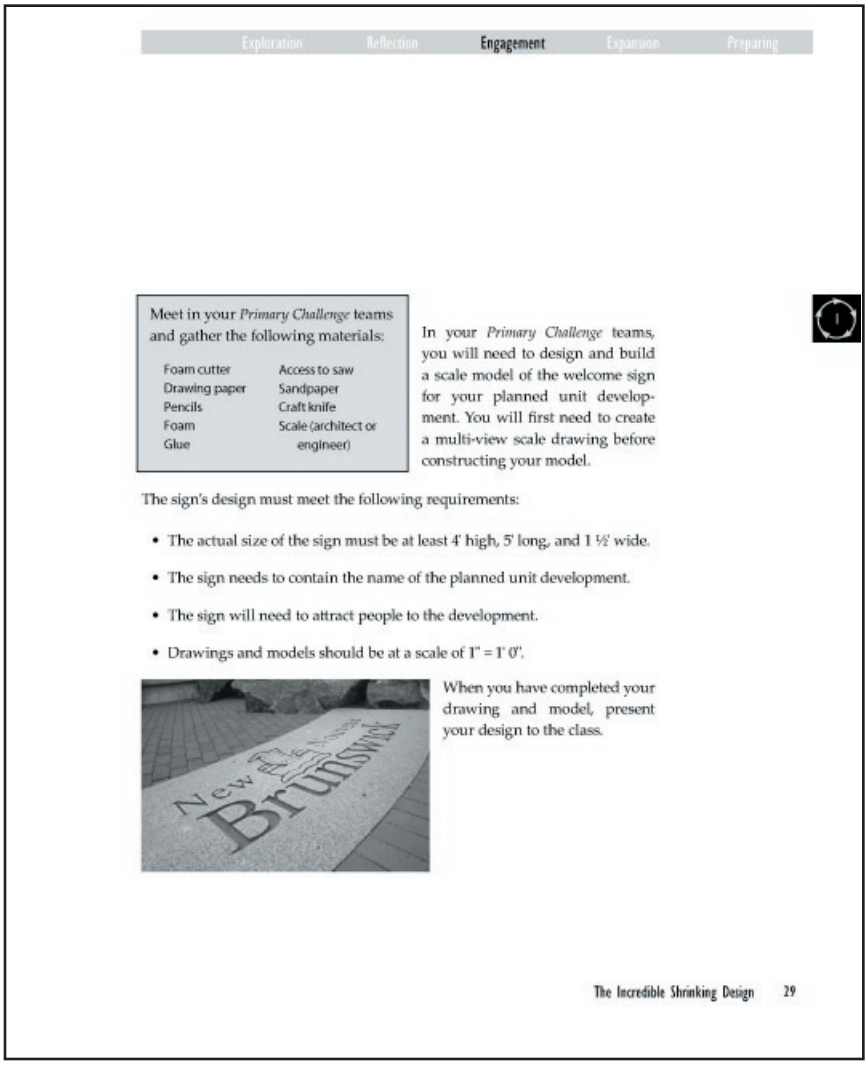
Foam sands very well, and even very rough surfaces can be cleaned up quickly. Foam can even be shaped by sanding or filing instead of cutting. One hundred-grit paper will cut very quickly. Four hundred-grit paper can produce a very smooth surface, especially if wet-sanded. The foam surface can tear if too much pressure is applied while sanding, so a very light touch should be used. Power sanding is possible if care is taken to not overheat and melt the foam. Sanding will produce a lot of dust. For this reason, many people prefer to wet sand, which contains the foam particles in the water.



Exploration Reflection **Engagement** Expansion Preparing

Meet in your *Primary Challenge* teams and gather the following materials:

Foam cutter	Access to saw
Drawing paper	Sandpaper
Pencils	Craft knife
Foam	Scale (architect or engineer)
Glue	

In your *Primary Challenge* teams, you will need to design and build a scale model of the welcome sign for your planned unit development. You will first need to create a multi-view scale drawing before constructing your model.

The sign's design must meet the following requirements:

- The actual size of the sign must be at least 4' high, 5' long, and 1 ½' wide.
- The sign needs to contain the name of the planned unit development.
- The sign will need to attract people to the development.
- Drawings and models should be at a scale of 1" = 1' 0".

When you have completed your drawing and model, present your design to the class.

The Incredible Shrinking Design 29

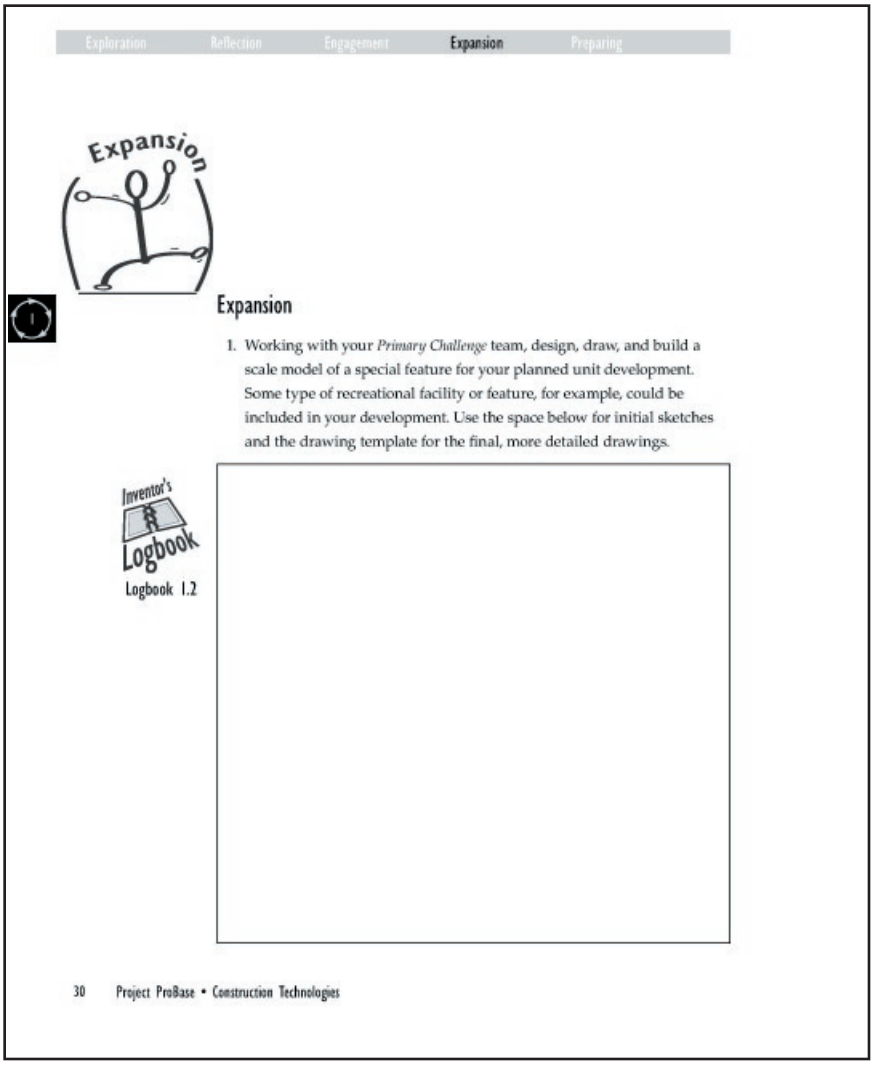
In general, students will find it easier and faster to model with foam than with wood. However, it is usually harder to obtain a smooth surface finish with foam. This difference should be kept in mind when evaluating student work.

Foam can be painted, although any paint containing acetone or similar solvents will dissolve the foam, creating a pitted and cratered surface. Most brush paints are suitable, but most spray paints are not. To use spray paint with foam, it is first necessary to seal the foam with shellac. Select a high-quality shellac that does not contain acetone (most do not) and be sure to completely seal the model. Even small holes will allow the spray paint to penetrate and dissolve the foam. Several layers of primer on top of the shellac will help level the surface and create a good base for a top coat.

Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explored in this learning cycle.

1. Working with your *Primary Challenge* team, design, draw, and build a scale model of a special feature for your planned unit development. Some type of recreational facility or feature, for example, could be included in your development. Use the space below for initial sketches and the drawing template for the final, more detailed drawings.



Exploration Reflection Engagement Expansion Preparing

Expansion

Expansion

1. Working with your *Primary Challenge* team, design, draw, and build a scale model of a special feature for your planned unit development. Some type of recreational facility or feature, for example, could be included in your development. Use the space below for initial sketches and the drawing template for the final, more detailed drawings.

Inventor's Logbook

Logbook 1.2

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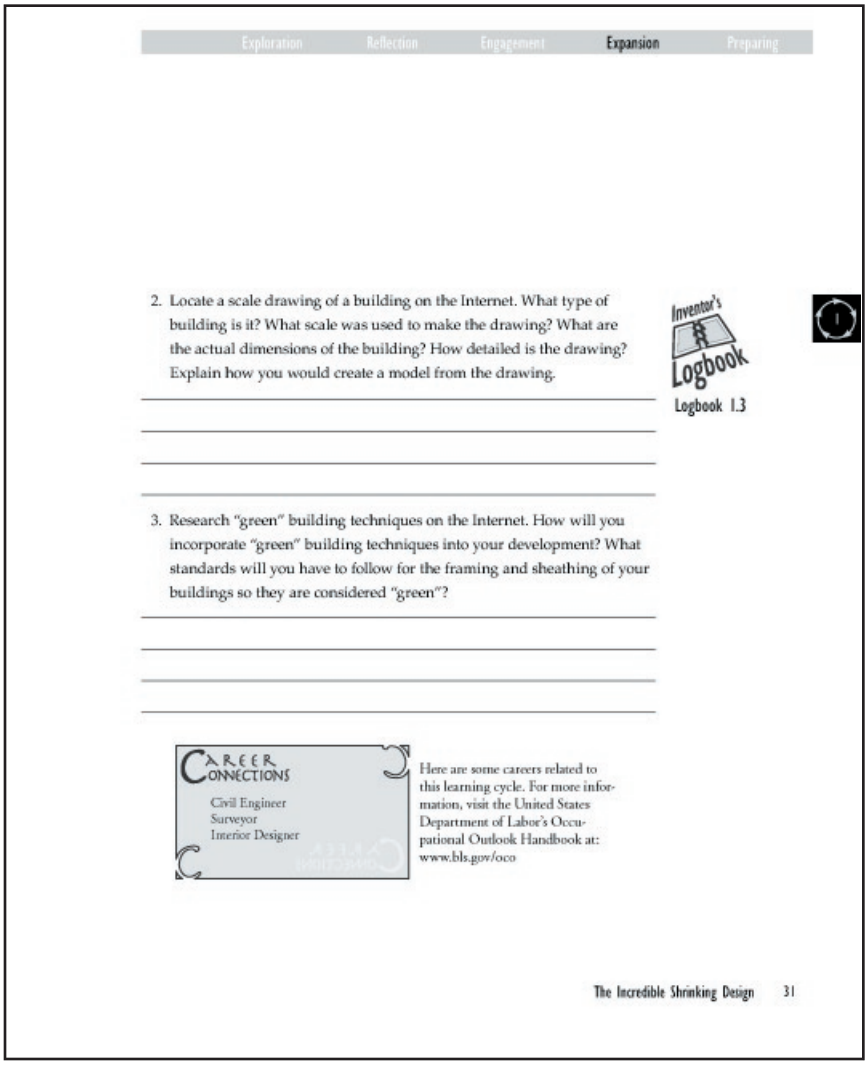


Exploration Reflection Engagement **Expansion** Preparing

2. Locate a scale drawing of a building on the Internet. What type of building is it? What scale was used to make the drawing? What are the actual dimensions of the building? How detailed is the drawing? Explain how you would create a model from the drawing.

Inventor's Logbook

Logbook 1.3

3. Research "green" building techniques on the Internet. How will you incorporate "green" building techniques into your development? What standards will you have to follow for the framing and sheathing of your buildings so they are considered "green"?

CAREER CONNECTIONS

Civil Engineer
Surveyor
Interior Designer

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

The Incredible Shrinking Design 31

2. Locate a scale drawing of a building on the Internet. What type of building is it? What scale was used to make the drawing? What are the actual dimensions of the building? How detailed is the drawing? Explain how you would create a model from the drawing.

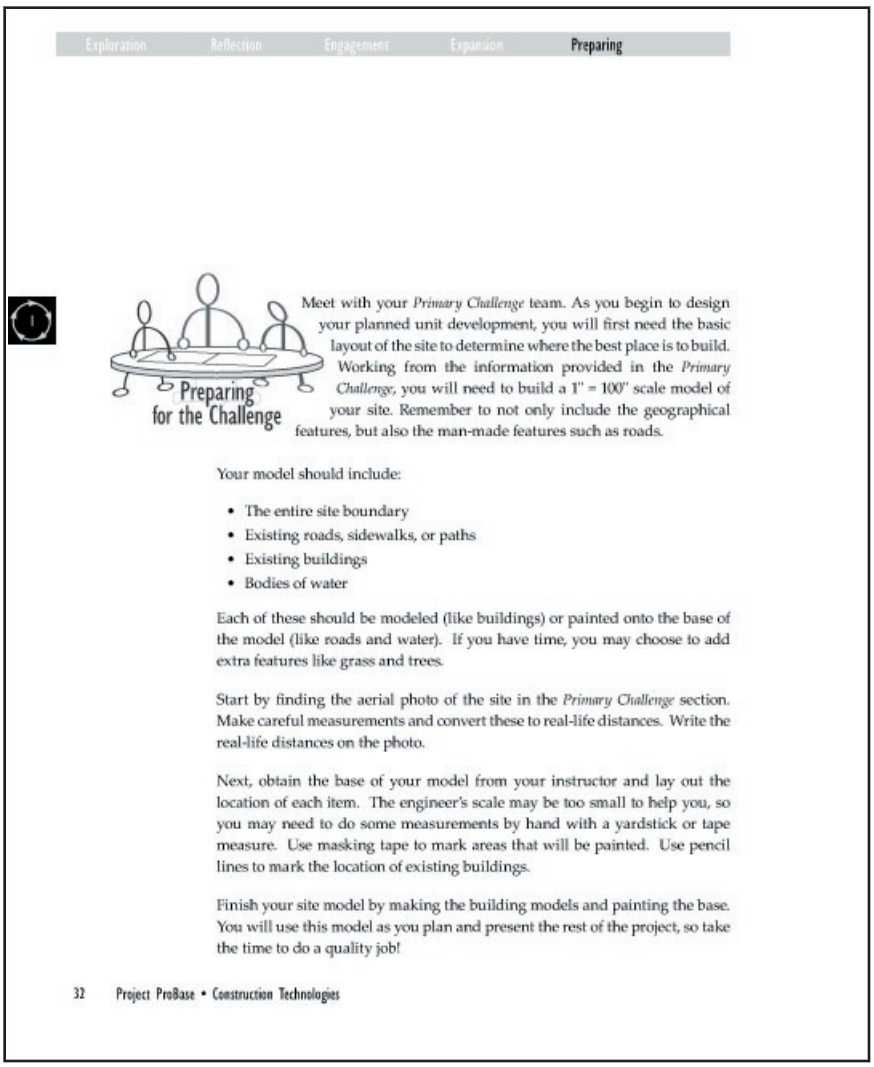
3. Research "green" building techniques on the Internet. How will you incorporate "green" building techniques into your development? What standards will you have to follow for the framing and sheathing of your buildings so they are considered "green"?

Preparing for the Challenge

Students should once again meet with their *Primary Challenge* teams. They are asked to design, draw, and build a model at the suggested 1:100 scale of the site for their planned unit development. The site model should be both accurate (to help future design work) and aesthetically pleasing (to improve the final presentation).

Students will need to take some time to make careful measurements from the aerial photo shown in the *Primary Challenge.* They should convert the actual measurements of the site into the correct scaled measurements. The model can be built using a half sheet of plywood or particle board.

Students should accurately lay out all dimensions on the base, which can then be cut and painted to match the dimensions. If time and budget allow, the site can be enhanced with landscaping items available for model railroading, such as simulated grass and trees.



Exploration Reflection Engagement Expansion **Preparing**

Meet with your *Primary Challenge* team. As you begin to design your planned unit development, you will first need the basic layout of the site to determine where the best place is to build. Working from the information provided in the *Primary Challenge*, you will need to build a 1" = 100' scale model of your site. Remember to not only include the geographical features, but also the man-made features such as roads.

Your model should include:

- The entire site boundary
- Existing roads, sidewalks, or paths
- Existing buildings
- Bodies of water

Each of these should be modeled (like buildings) or painted onto the base of the model (like roads and water). If you have time, you may choose to add extra features like grass and trees.

Start by finding the aerial photo of the site in the *Primary Challenge* section. Make careful measurements and convert these to real-life distances. Write the real-life distances on the photo.

Next, obtain the base of your model from your instructor and lay out the location of each item. The engineer's scale may be too small to help you, so you may need to do some measurements by hand with a yardstick or tape measure. Use masking tape to mark areas that will be painted. Use pencil lines to mark the location of existing buildings.

Finish your site model by making the building models and painting the base. You will use this model as you plan and present the rest of the project, so take the time to do a quality job!

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Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your needs.

The Incredible Shrinking Design

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Exploration	Successfully completed calculations and scale drawing; followed all guidelines.	Successfully completed most of the calculations and scale drawing; met most of the guidelines.	Encountered difficulty with the calculations and scale drawing; did not meet all guidelines.	Did not successfully complete the calculations nor the scale drawing; did not meet guidelines.	
Engagement	Successfully designed sign, drew, and modeled to scale; worked well within group; met all specifications.	Successfully designed sign, drew, and modeled to scale; worked well within group; met most of the specifications.	Encountered difficulty with design of sign and with scaled drawing and model; experienced difficulty in group; did not meet all specifications.	Did not successfully design, draw, or model sign; did not work well in group; met few specifications.	
Inventor's Logbook Entries	Completely answered all entries.	Completely answered most of the entries.	Answered few entries completely.	Did not answer entries.	
Preparing for the Challenge	Successfully measured, modeled, and painted site; worked well as a group.	Measured, modeled, and painted site well; worked well as a group.	Encountered problems measuring, modeling, and painting site; difficulty working in group.	Did not successfully measure, model, and paint site; did not work well in group.	
				Total	

Learning Cycle Two

Community Architecture

2

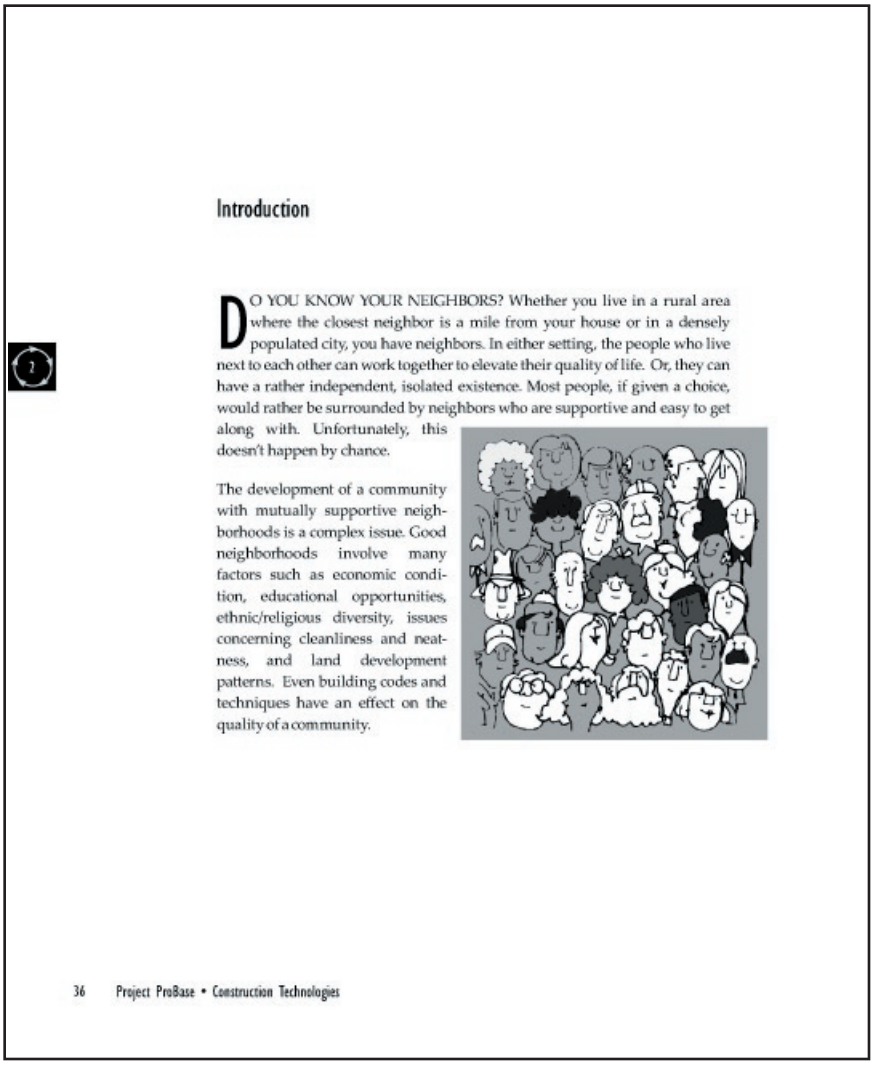
Community Architecture

Introduction

This learning cycle requires students to analyze and design the elements that promote positive and negative interaction between residents of a community. Students will first investigate an existing neighborhood near their home or school, gather data, form opinions, and present conclusions. This is followed by a chance to design improvements to the neighborhood that they have investigated. Finally, the concepts acquired in the preceding activities are extended to design work on the *Primary Challenge*.

The initial activities in this learning cycle take place largely outside the classroom. To some extent, the success of the learning cycle depends on these factors:

1. The neighborhoods the students will study.
2. The students' interest and motivation to gather information about a neighborhood.
3. Your ability to engage students in a discussion that will actually bring out characteristics.



Introduction

DO YOU KNOW YOUR NEIGHBORS? Whether you live in a rural area where the closest neighbor is a mile from your house or in a densely populated city, you have neighbors. In either setting, the people who live next to each other can work together to elevate their quality of life. Or, they can have a rather independent, isolated existence. Most people, if given a choice, would rather be surrounded by neighbors who are supportive and easy to get along with. Unfortunately, this doesn't happen by chance.

The development of a community with mutually supportive neighborhoods is a complex issue. Good neighborhoods involve many factors such as economic condition, educational opportunities, ethnic/religious diversity, issues concerning cleanliness and neatness, and land development patterns. Even building codes and techniques have an effect on the quality of a community.

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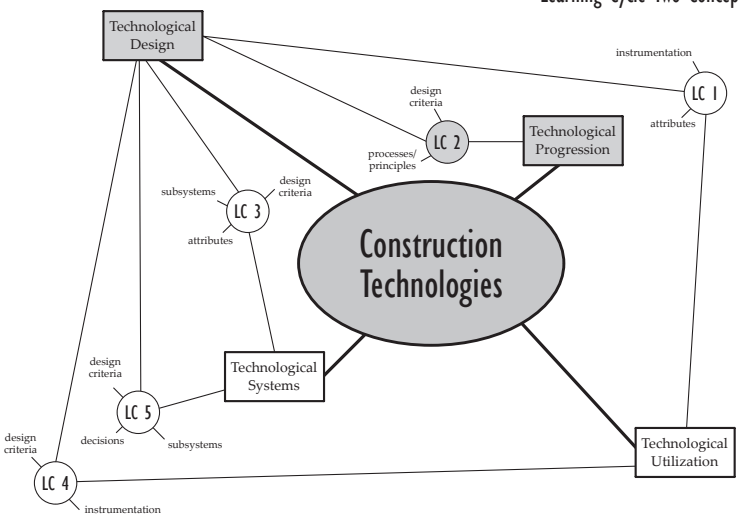
ConstructionTechnologies
Learning Cycle Two Concept Map



In this learning cycle, you will learn how the physical characteristics of a neighborhood affect the quality of life of its residents. You will also have an opportunity to use what you have learned to design building elements that will promote better land use and contribute to the development of a neighborhood where everyone knows and supports one another.

You might wonder why you need to learn about quality of life issues in building design. Only a small percentage of people need these skills professionally as city planners, architects, or land developers. On the other hand, everyone has to think about finding a place to live. At some time in your life, you will have to look at the advantages and disadvantages of living in a given neighborhood.

Objectives

After completing this learning cycle, you will be able to:

1. Identify physical characteristics that promote or hinder interaction among residents of a neighborhood.
2. Design appropriate features for a new or existing neighborhood to encourage community interaction.

Community Architecture 37

It is recommended that you read the complete learning cycle prior to instruction. By doing this, you will be able to make any adjustments needed so that students can master the content while also enjoying the unique activities included in this learning cycle.

It is also highly recommended that you begin this learning cycle by inviting a civil engineer, architect, or regional or city planner to come to the class as a guest speaker. By initiating the unit with a guest speaker, the students are much more likely to attack this problem with energy—and good questions.

Objectives and Essential Questions

After completing this learning cycle, students will be able to:

1. Identify physical characteristics that promote or hinder interaction among residents of a neighborhood.

Essential Question 1e: What are the fundamental processes/principles used to develop new technologies?

2. Design appropriate features for a new or existing neighborhood to encourage community interaction.

Essential Question 7c: What design criteria are typically considered when developing new technologies and how do these influence the final product/system design?

Facility Requirements

No special facilities are required for this learning cycle. However, a significant portion of the *Exploration* activity will need to be done outside of the classroom.

Equipment and Materials

8 ½" x 11" white paper

Graph paper

Pencils and erasers

Masking tape and transparent tape

Tracing paper (optional, roll of 24" x 150' recommended)

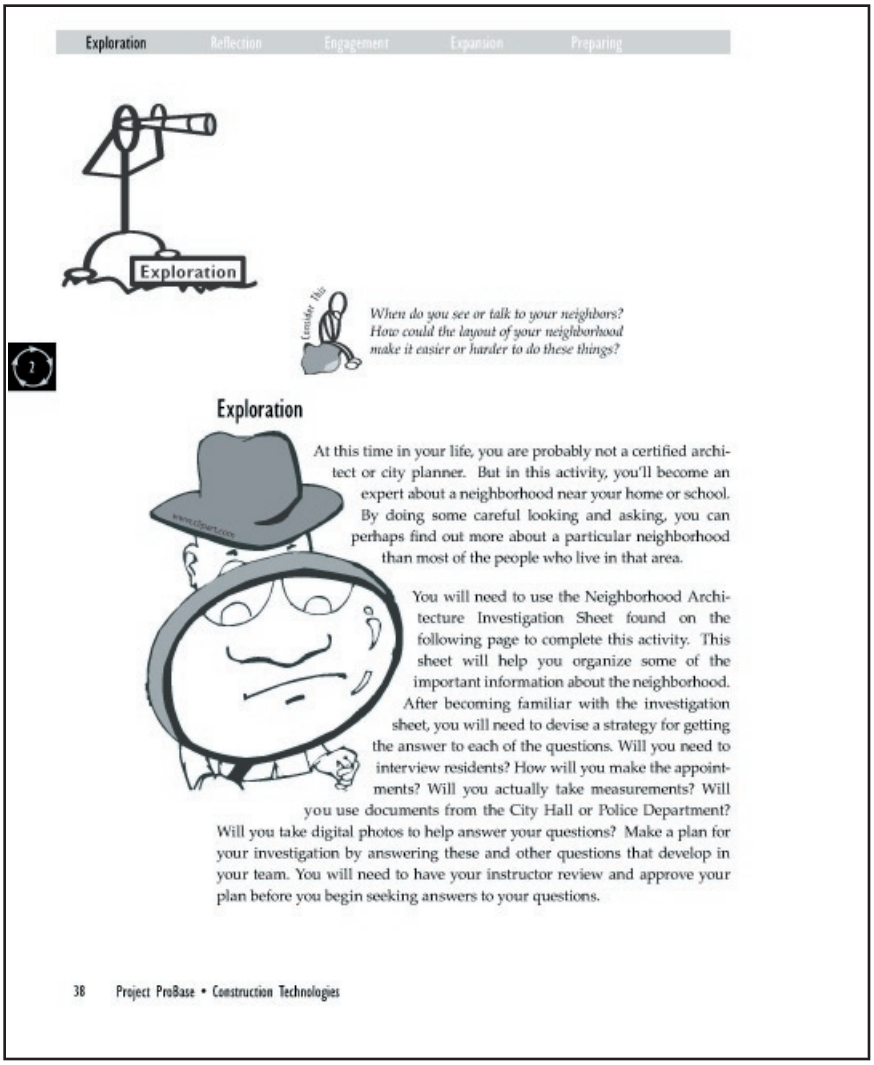
Color markers (optional)

Digital camera (optional)

Computers and printers

City or county map

Local building codes



Exploration Reflection Engagement Expansion Preparing

Exploration

Consider This

When do you see or talk to your neighbors? How could the layout of your neighborhood make it easier or harder to do these things?

2

Exploration

At this time in your life, you are probably not a certified architect or city planner. But in this activity, you'll become an expert about a neighborhood near your home or school. By doing some careful looking and asking, you can perhaps find out more about a particular neighborhood than most of the people who live in that area.

You will need to use the Neighborhood Architecture Investigation Sheet found on the following page to complete this activity. This sheet will help you organize some of the important information about the neighborhood. After becoming familiar with the investigation sheet, you will need to devise a strategy for getting the answer to each of the questions. Will you need to interview residents? How will you make the appointments? Will you actually take measurements? Will you use documents from the City Hall or Police Department? Will you take digital photos to help answer your questions? Make a plan for your investigation by answering these and other questions that develop in your team. You will need to have your instructor review and approve your plan before you begin seeking answers to your questions.

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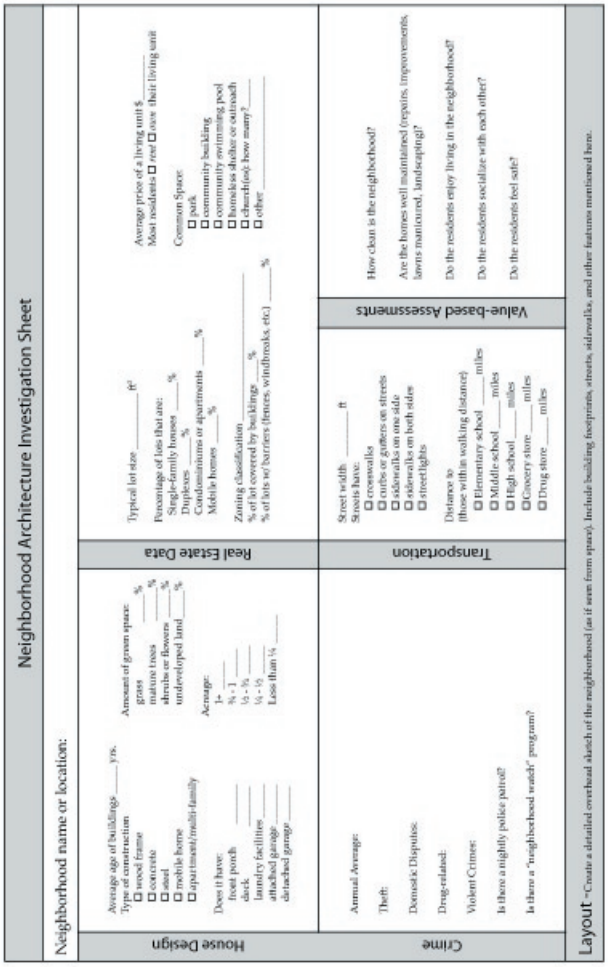
Suggested Daily Outline

Estimated number of 50-minute class periods: **4**

Day One	Day Two
Introduction, *Exploration*	*Exploration*
Day Three	**Day Four**
Reflection, Engagement	*Engagement,* Preparing for the Challenge



Neighborhood Architecture Investigation Sheet

Neighborhood name or location:

House Design

Average age of buildings _____ yrs.
Type of construction
☐ wood frame
☐ concrete
☐ steel
☐ mobile home
☐ apartment/multi-family

Does it have:
front porch _____
deck _____
laundry facilities _____
attached garage _____
detached garage _____

Amount of green space:
grass _____ %
native trees _____ %
shrubs or flowers _____ %
undeveloped land _____ %

Acreage:
1+ _____
¾ - 1 _____
½ - ¾ _____
¼ - ½ _____
Less than ¼ _____

Real Estate Data

Typical lot size _____ ft²

Percentage of lots that are:
Single-family houses _____ %
Duplexes _____ %
Condominiums or apartments _____ %
Mobile homes _____ %

Zoning classification _____
% of lot covered by buildings _____ %
% of lots w/ barriers (fences, windbreaks, etc) _____ %

Average price of a living unit $ _____
Most residents ☐ rent ☐ own their living unit

Common Space:
☐ park
☐ community building
☐ community swimming pool
☐ homeless shelter or outreach
☐ church(es): how many? _____
☐ other: _____

Crime

Annual Average:

Theft:

Domestic Disputes:

Drug-related:

Violent Crimes:

Is there a nightly police patrol?

Is there a "neighborhood watch" program?

Transportation

Street width _____ ft
Streets have:
☐ crosswalks
☐ curbs or gutters on streets
☐ sidewalks on one side
☐ sidewalks on both sides
☐ streetlights

Distance to
(those within walking distance)
☐ Elementary school _____ miles
☐ Middle school _____ miles
☐ High school _____ miles
☐ Grocery store _____ miles
☐ Drug store _____ miles

Value-based Assessments

How clean is the neighborhood?

Are the homes well maintained (repairs, improvements, lawns manicured, landscaping)?

Do the residents enjoy living in the neighborhood?

Do the residents socialize with each other?

Do the residents feel safe?

Layout - Create a detailed overhead sketch of the neighborhood (as if seen from space). Include building footprints, streets, sidewalks, and other features mentioned here.

Exploration

The focus of the *Exploration* activity is on physical characteristics of communities that influence residents' quality of life. Students are asked to gather real data on an existing neighborhood and then make connections to answer specific questions about community interaction. It is recommended that students work in pairs and that the pairs be assigned by the instructor.

Detailed local maps are important, preferably ones that show individual lots and buildings on those lots. The town or city hall, real estate offices, or the county/parish extension office may be able to help. An alternative is to use aerial or satellite photography instead. Most areas of the United States are covered by government aerial photographs available freely on the Internet (http://www.terraserver.microsoft.com). When using the photos, make sure to record scale data with the photograph, so that students can make useful measurements. Scale data in digital photos is often given in meters per pixel.

Teaching tips

You may want to substitute the "Neighborhood Architecture Investigation Sheet" with a profile sheet used by realtors in the evaluation of neighborhoods and properties. For example, the real estate agency Remax has a profile sheet on its website (http://www.remax.com). You can select homes by zip code and click on "Compare Neighborhoods" to learn about the physical characteristics of surrounding neighborhoods.

Teaching Tips

Decide in advance which neighborhoods the students are going to study. For more diversity, instead of having the students gather information about their own neighborhood, it would be good to have a newer development, a well established neighborhood that is well maintained, a neighborhood with common space (park, golf course, or community building), one that is in decline, one that has a reputation of being "alternative," and so forth. Some neighborhoods have logical physical boundaries while others do not. It is recommended that the areas that students study are approximately the size of the one presented in the *Primary Challenge* (about ten acres).

2

Before you engage students in this *Exploration* it is recommend that you know some characteristics of neighborhoods from personal experience. Some factors in positive community interaction are given here:

1. Neighborhood has space held "in common." Some neighborhoods are built around common spaces like parks, playgrounds, school grounds, and golf courses. Spaces of this kind tend to bring people together and this naturally promotes interaction.

2. There is a community building supported by resident fees. A community building can offer many opportunities for residents to associate with one another. Sample services include: a common place to pick up mail, a space for a nursery/pre-school, a wellness/exercise center, a meeting area for meals (once a month barbecues, pot lucks, etc.), and a swimming pool.

3. Barriers between lots are minimized. Fences, windbreaks, and outward-facing lots have advantages in some cases, but also help to isolate residents from their nearest neighbors.

4. Community organizations are strong. Some communities have developed a "Neighborhood Watch" and community revitalization organizations to bring neighbors together for a common cause. In a similar vein, on a very informal basis some neighborhoods have annual block parties or barbecues that bring neighbors together. They arrange for the city to restrict access to their streets so children can use them for games for one afternoon. Neighborhoods of this type tend to develop a reputation for being a good place to live. In many cases this reputation adds value to the properties because many families seek this type of a place to rear their children.

5. Students can walk to school in a safe environment. This offers more convenience for the families and it saves energy over time. Sometimes parents walk with their children and this offers an opportunity for parents to know the neighborhood children.

6. Shopping for basic necessities is within walking distance. If schools and shopping are within walking distance, a family may be able to survive with only one car. Parents and children may be outside more on their way to and from errands.

7. There is a good proportion of green space and a diversity of trees, shrubs, flowers, etc. Vegetation not only provides oxygen necessary for human and animal life, it does much to beautify the environment.

8. The natural environment is left undeveloped. Many sites that are developed for commercial and housing units have natural characteristics such as wetlands, trees, and streams that could be worked into the design of a new development. Developments that strip the entire site often create a sterile atmosphere that gives the impression of houses as islands.

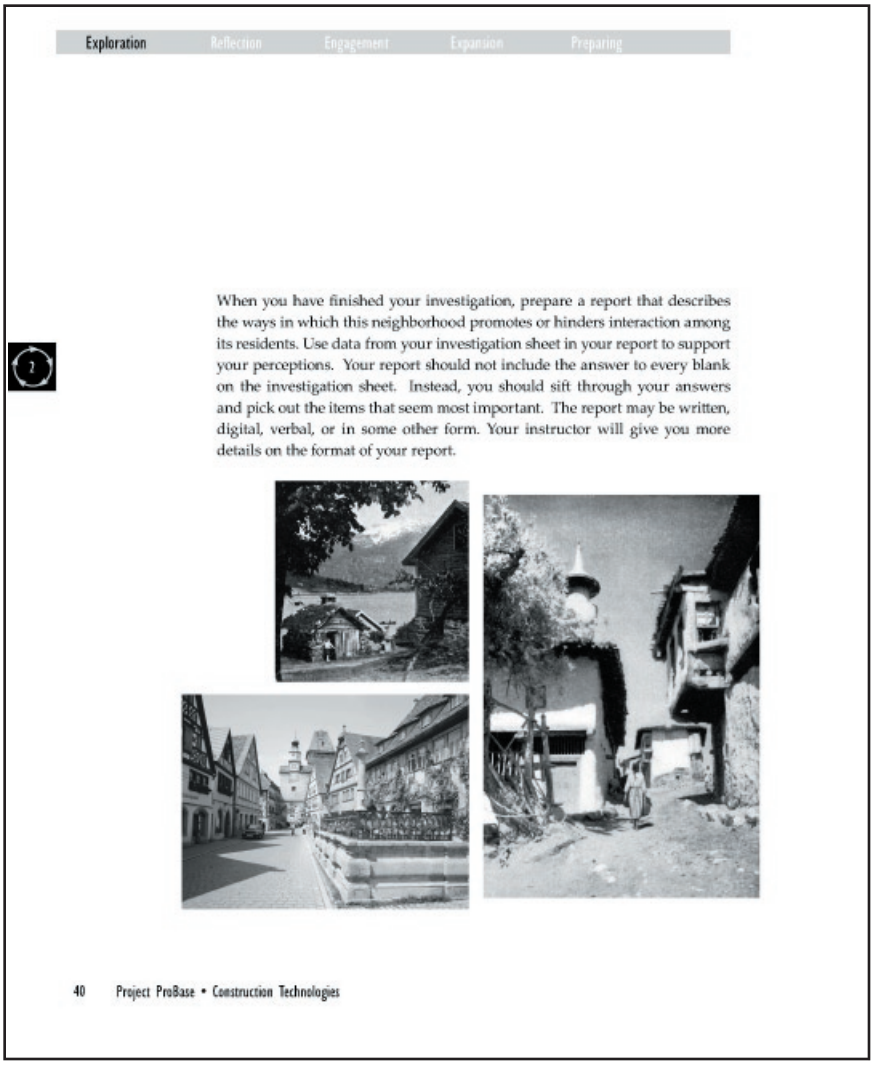
Teaching Tips

For a professional perspective, you may want to invite a realtor or property inspector to your classroom to discuss their occupations. The realtor could discuss what he or she looks for when preparing a home for sale. The property inspector could talk about the potential problems with homes (water damage, termite damage, foundation cracks, etc.) from a buyer's perspective.

It will be a challenge to get students to develop ideas like these without giving them too much help. In some cases you may have to ask questions to get them to recall features of the neighborhoods they studied. It is common for some students to resist gathering information in a neighborhood. It would help for you to recommend certain people that would gladly help students.

Students will also create a scale drawing of their neighborhood to synthesize some of the features that they have observed. This should be an orthographic top view, but does not have to be to full map-drafting quality. The important thing is to include those elements noted on the data sheet. If time is short, a simpler alternative is for students to create the drawing on graph paper. In either case, a scale of 1'=100" is recommended.

Once students have lightly penciled in the roads, parks, buildings, etc., it would help to color-code various features. For example, one color might be used for roads, another for commercial buildings, another for schools and parks, another for housing units, etc. This not only makes the drawings attractive, but it helps communicate land use in a neighborhood.



Exploration Reflection Engagement Expansion Preparing

When you have finished your investigation, prepare a report that describes the ways in which this neighborhood promotes or hinders interaction among its residents. Use data from your investigation sheet in your report to support your perceptions. Your report should not include the answer to every blank on the investigation sheet. Instead, you should sift through your answers and pick out the items that seem most important. The report may be written, digital, verbal, or in some other form. Your instructor will give you more details on the format of your report.

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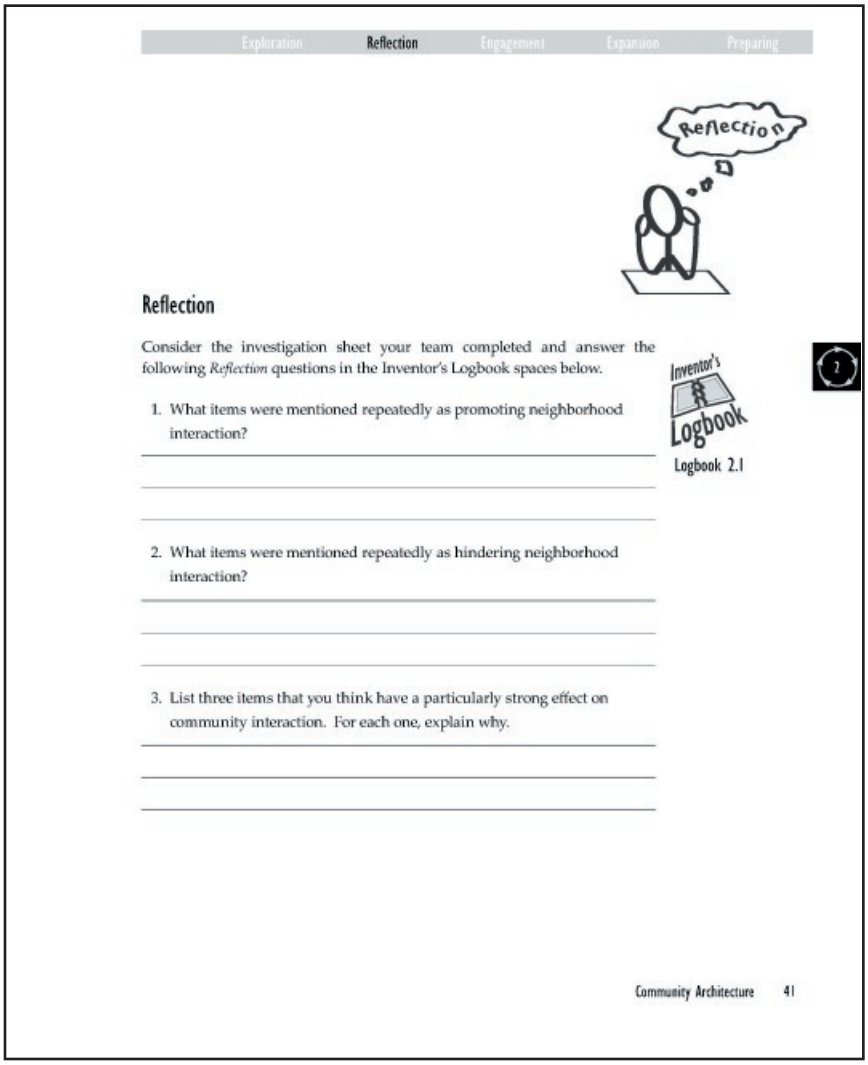

Exploration Reflection Engagement Expansion Preparing

Reflection

Consider the investigation sheet your team completed and answer the following *Reflection* questions in the Inventor's Logbook spaces below.

Inventor's Logbook

Logbook 2.1

1. What items were mentioned repeatedly as promoting neighborhood interaction?

2. What items were mentioned repeatedly as hindering neighborhood interaction?

3. List three items that you think have a particularly strong effect on community interaction. For each one, explain why.

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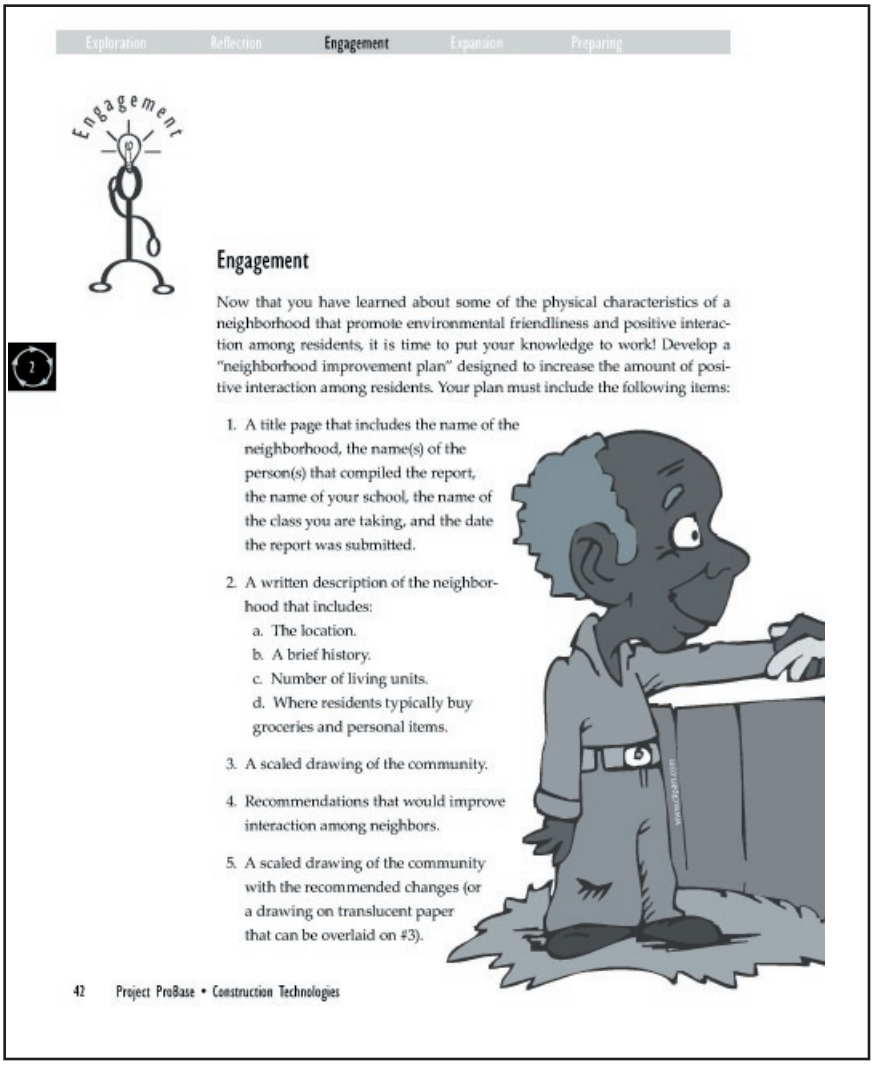
Reflection

As students answer the *Reflection* questions provided in the Student Guide, it may help to have the class discuss some of the ideas presented. Example questions are provided below:

1. How does a neighborhood with single-family homes feel different than one with multi-family buildings?
2. Why is it beneficial to have businesses that carry basic necessities within walking distance to one's home?
3. What is the value of a park in a community?
4. Why are trees, shrubs, and flowers important to a neighborhood?
5. Why do a lot of families want a neighborhood elementary school?

Engagement

During this phase of the learning cycle, students will have a chance to put their new knowledge to work. Now, they have a chance to actually make a difference in a neighborhood in their own community. Students are assigned the neighborhood improvement plan. The more resources you can provide, the better. An Internet search for "Green Communities," "Sustainable Communities," "Community Sprawl," Efficient Housing," and "Community Networks," will provide the class with a lot of information to consider as students come up with recommendations for their assigned neighborhood.



Exploration Reflection **Engagement** Expansion Preparing

Engagement

Engagement

Now that you have learned about some of the physical characteristics of a neighborhood that promote environmental friendliness and positive interaction among residents, it is time to put your knowledge to work! Develop a "neighborhood improvement plan" designed to increase the amount of positive interaction among residents. Your plan must include the following items:

1. A title page that includes the name of the neighborhood, the name(s) of the person(s) that compiled the report, the name of your school, the name of the class you are taking, and the date the report was submitted.
2. A written description of the neighborhood that includes:
   a. The location.
   b. A brief history.
   c. Number of living units.
   d. Where residents typically buy groceries and personal items.
3. A scaled drawing of the community.
4. Recommendations that would improve interaction among neighbors.
5. A scaled drawing of the community with the recommended changes (or a drawing on translucent paper that can be overlaid on #3).

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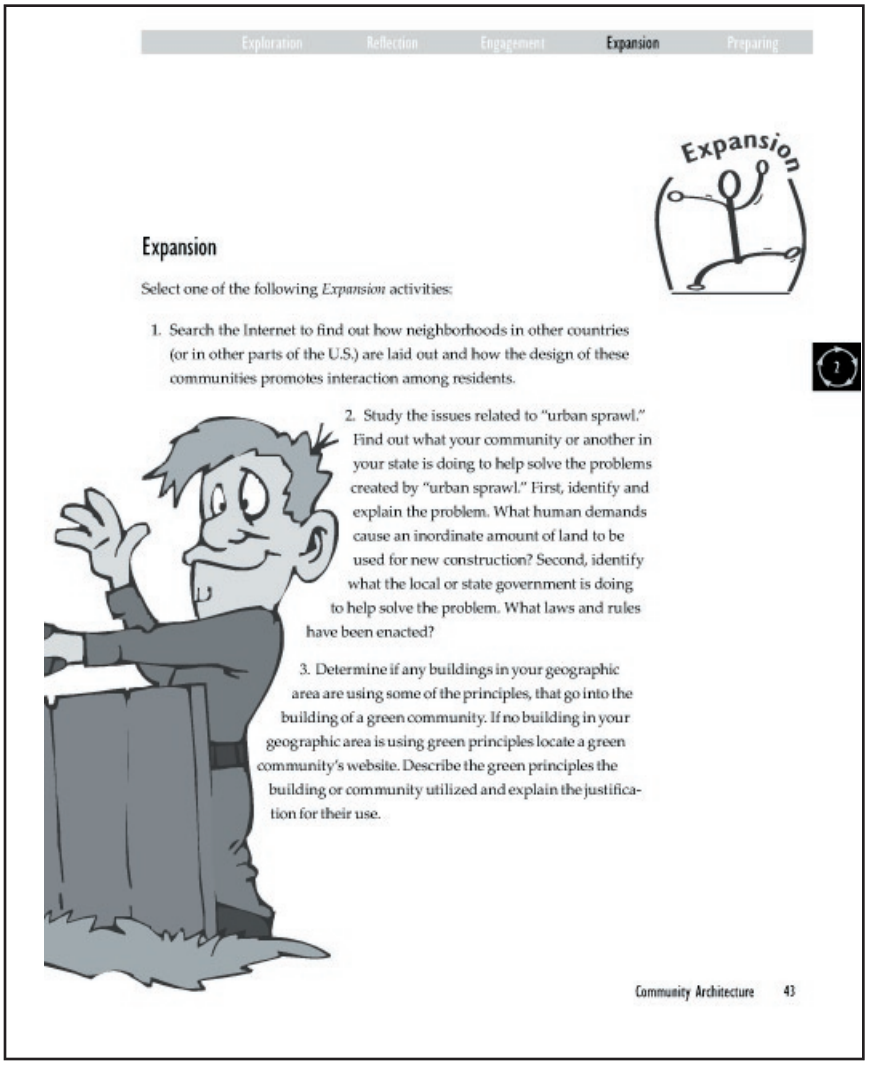
Students already made drawings of the neighborhoods assigned to them. The drawings for the neighborhood improvement plan can simply be tracings of these drawings or an overlay on translucent paper that includes the recommended changes. Be on the alert for real-life audiences that would benefit from the students' work. A community board, city council, or neighborhood organization meeting may be interested in hearing a presentation of the work, and students can help raise the profile of their school course work in technology.



Exploration Reflection Engagement Expansion Preparing

Expansion

Expansion

Select one of the following *Expansion* activities:

1. Search the Internet to find out how neighborhoods in other countries (or in other parts of the U.S.) are laid out and how the design of these communities promotes interaction among residents.

2. Study the issues related to "urban sprawl." Find out what your community or another in your state is doing to help solve the problems created by "urban sprawl." First, identify and explain the problem. What human demands cause an inordinate amount of land to be used for new construction? Second, identify what the local or state government is doing to help solve the problem. What laws and rules have been enacted?

3. Determine if any buildings in your geographic area are using some of the principles, that go into the building of a green community. If no building in your geographic area is using green principles locate a green community's website. Describe the green principles the building or community utilized and explain the justification for their use.

Community Architecture 43

Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explored in this learning cycle.

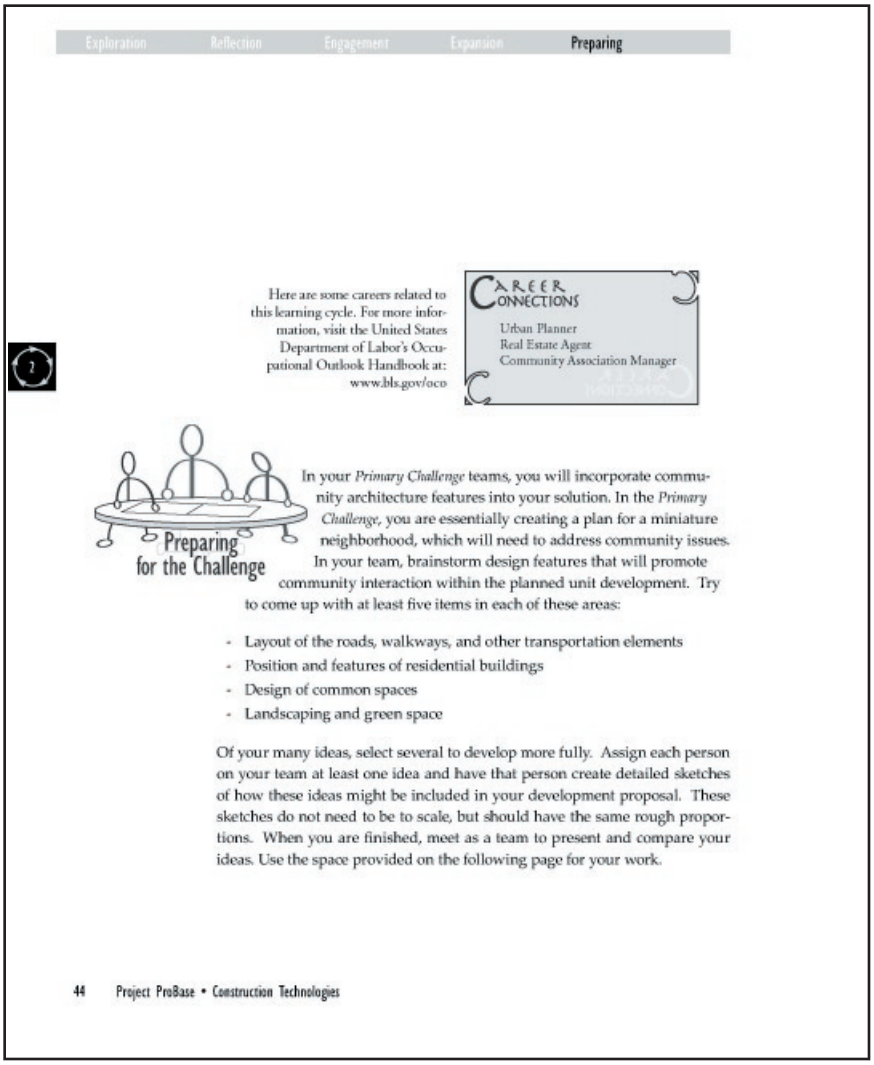
1. Search the Internet to find out how neighborhoods in other countries (or in other parts of the U.S.) are laid out and how the design of these communities promotes interaction among residents.

2. Study the issues related to "urban sprawl." Find out what your community or another in your state is doing to help solve the problems created by "urban sprawl." First, identify and explain the problem. What human demands cause an inordinate amount of land to be used for new construction? Second, identify what the local or state government is doing to help solve the problem. What laws and rules have been enacted?

3. Determine if any buildings in your geographic area are using some of the principles that go into the building of a green community. If no building in your geographic area is using green principles, locate a green community's website. Describe the green principles the building or community utilized and explain the justification for their use.

Preparing for the Challenge

To encourage efficient work, students should start their work on the *Primary Challenge* by making an outline of the site they will be developing. This should, of course, be to scale. They should also make an outline or "footprint" for a community building, commercial buildings, a variety of living units, and community features such as park areas, fountains, walks, etc. They can then place the footprints of the various items on the building site, moving them around to explore different options. When they are satisfied with a layout, they can then trace the outlines on tracing paper. The result can serve as their design "A." Students should be encouraged to make several more—a design "B," "C," and so on. Each time they will discover ways to improve their design.



Exploration Reflection Engagement Expansion **Preparing**

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

CAREER CONNECTIONS

Urban Planner
Real Estate Agent
Community Association Manager

Preparing for the Challenge

In your *Primary Challenge* teams, you will incorporate community architecture features into your solution. In the *Primary Challenge*, you are essentially creating a plan for a miniature neighborhood, which will need to address community issues. In your team, brainstorm design features that will promote community interaction within the planned unit development. Try to come up with at least five items in each of these areas:

- Layout of the roads, walkways, and other transportation elements
- Position and features of residential buildings
- Design of common spaces
- Landscaping and green space

Of your many ideas, select several to develop more fully. Assign each person on your team at least one idea and have that person create detailed sketches of how these ideas might be included in your development proposal. These sketches do not need to be to scale, but should have the same rough proportions. When you are finished, meet as a team to present and compare your ideas. Use the space provided on the following page for your work.

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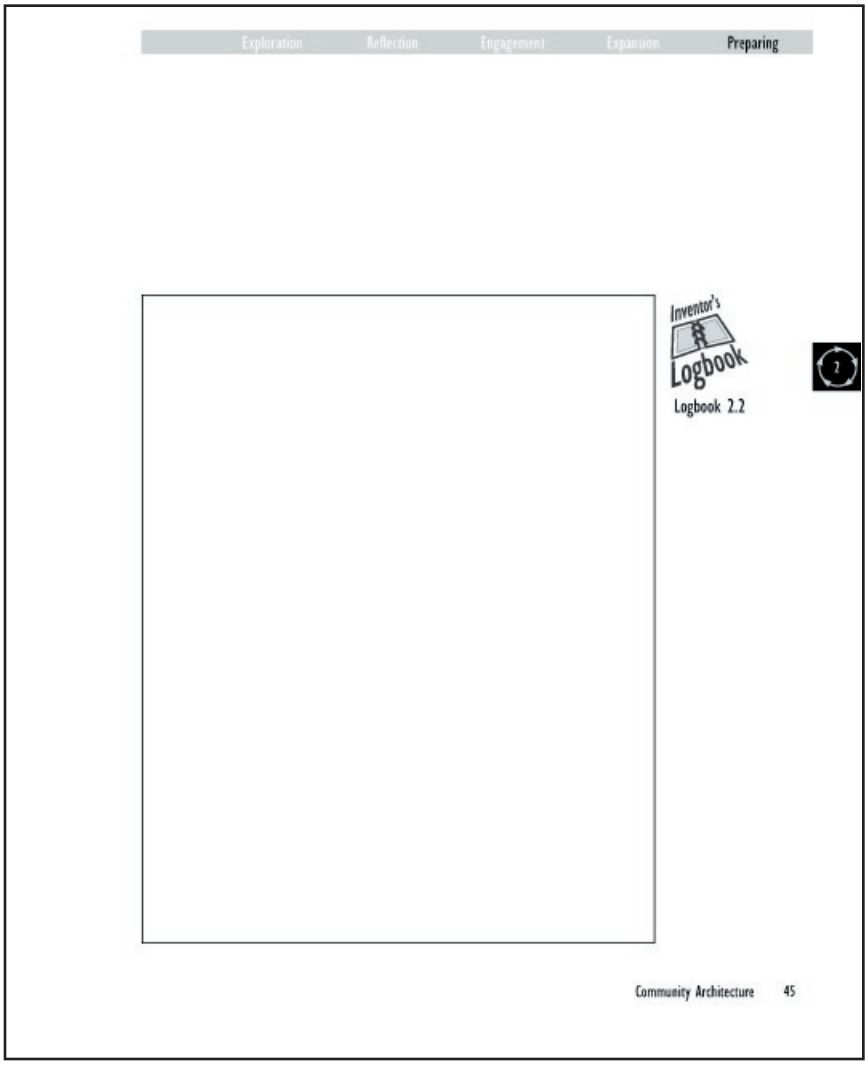


Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your needs.

Community Architecture Rubric

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Initial report on neighborhood	Includes specific items that are based on data from personal investigation.	Includes specific items that are based on general concepts.	Includes general items specific to this neighborhood.	Includes general items common to many neighborhoods.	
Description of neighborhood	Includes location, history, size, number of living units, and shopping areas.	Includes most elements requested in the description; history is included.	The description addresses about half of what is expected.	The description includes very few of the elements requested.	
Drawing of existing community	Scale is in proportion and all buildings, roads, etc. are on the drawing.	Nearly all of the buildings and roads are represented.	There are problems with the scale; some buildings are not represented.	The scale is inaccurate; many buildings are missing.	
Recommendations	There are at least six recommendations representing both environmental concerns and ways to increase interaction.	Four or five feasible recommendations were given.	Two or three feasible recommendations were given.	One or no recommendations were given	
Drawing with proposed changes	Drawing is to scale; includes buildings, roads, etc. and represents own recommendations.	Drawing has some missing information and may have scale problems.	There may be problems with the scale; about one half of the information is missing.	Drawing is not to scale; has limited information.	
				Total Points	

Learning Cycle Three

The Web We Weave

3

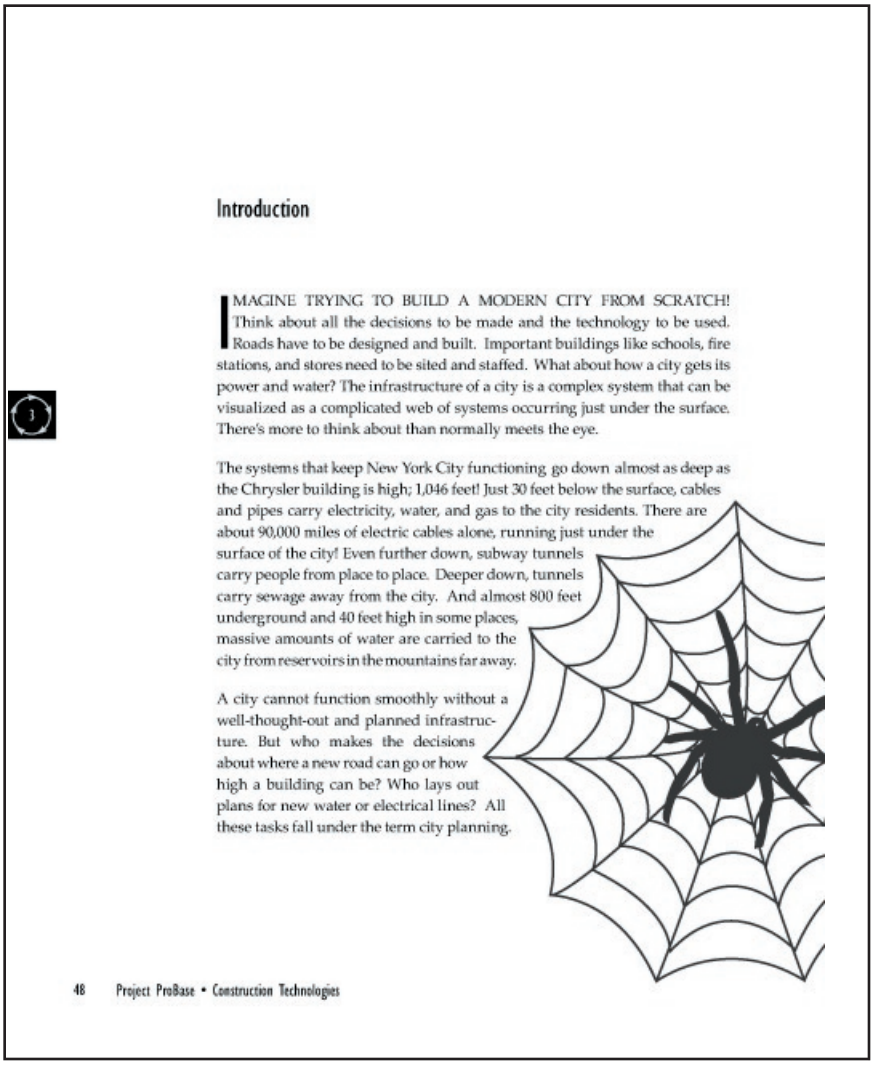
The Web We Weave

Introduction

Throughout this learning cycle students will explore different infrastructure systems that are involved in most large-scale construction. Student teams will first construct an aqueduct system designed to carry water twenty feet up a two-foot grade. After students have timed how long it takes to transport water through their systems, they will compare their results to a pump-fed system.

In the second *Exploration* activity, students will redesign a parking facility to help a school manage its use of land. Students will need to think through many different factors in order to design a practical and convenient facility. During the *Engagement* activity, students will be assigned to groups representing different interests in developing a piece of land. The student groups will need to produce a proposal that addresses seven criteria and includes a parking management plan.

Each group will give a presentation covering the specified requirements. After all presentations, the class will discuss the best use of the land according to different needs. *Preparing for the Challenge* allows time for the students to create a concept plan for their planned unit development. Their concept plan must include the outlined dimensions and a scaled drawing.



Introduction

IMAGINE TRYING TO BUILD A MODERN CITY FROM SCRATCH! Think about all the decisions to be made and the technology to be used. Roads have to be designed and built. Important buildings like schools, fire stations, and stores need to be sited and staffed. What about how a city gets its power and water? The infrastructure of a city is a complex system that can be visualized as a complicated web of systems occurring just under the surface. There's more to think about than normally meets the eye.

The systems that keep New York City functioning go down almost as deep as the Chrysler building is high; 1,046 feet! Just 30 feet below the surface, cables and pipes carry electricity, water, and gas to the city residents. There are about 90,000 miles of electric cables alone, running just under the surface of the city! Even further down, subway tunnels carry people from place to place. Deeper down, tunnels carry sewage away from the city. And almost 800 feet underground and 40 feet high in some places, massive amounts of water are carried to the city from reservoirs in the mountains far away.

A city cannot function smoothly without a well-thought-out and planned infrastructure. But who makes the decisions about where a new road can go or how high a building can be? Who lays out plans for new water or electrical lines? All these tasks fall under the term city planning.

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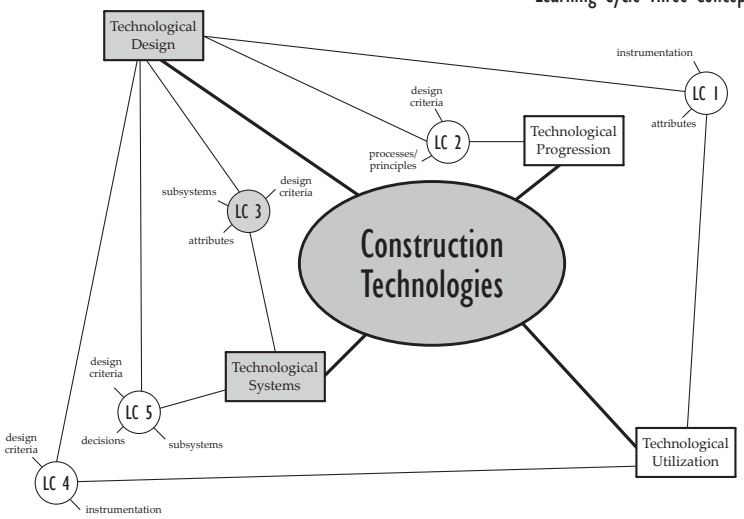
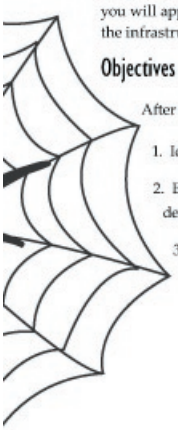
ConstructionTechnologies
Learning Cycle Three Concept Map



City planners deal with a broad range of city needs including buildings, utilities, and roads. Most importantly, city planners decide how to allocate one of the city's most precious resources: land.

The term infrastructure denotes the set of interconnected structural elements and facilities that provide the framework for supporting a specific land use or built environment. In this learning cycle, you will learn about the many different infrastructural decisions that must be made when planning any type of large-scale construction. First, you will have the opportunity to trace the evolution of one important utility: water. Then, you will have a chance to analyze trade-offs for one major use of city land–automobile parking. Finally, you will apply what you have learned to the *Primary Challenge* and determine the infrastructure for your planned unit development.



Objectives

After completing this learning cycle, you will be able to:

1. Identify the infrastructural elements of a city.
2. Explain the ways in which infrastructural elements are chosen, designed, and regulated.
3. Create a system of infrastructural elements, including water and parking.

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Objectives and Essential Questions

After completing this learning cycle, students will be able to:

1. Identify the infrastructural elements of a city.

Essential Question 4a: What are the systems and subsystems involved in the various contexts of technology?

2. Explain the ways in which infrastructural elements are chosen, designed, constructed, and regulated.

Essential Question 7c: What design criteria are typically considered when developing new technologies (e.g., marketability, safety, usability, reliability, cost, materials, etc.) and how do these influence the final product/system design?

3. Develop a concept plan meeting specified criteria for a planned development.

Essential Question 7e: How can the attributes of design and the principles of design aid in the development of quality solutions?

Facility Requirements

During the first *Exploration* phase, students will need access to a lab setting or a space where they can build their 20-foot long aqueduct system. Some water may spill during this activity. For the remaining activities, students will need access to computers and space for group work, including large flat surfaces for planning.

Equipment/Materials

Exploration I

Plastic straws

Masking tape

Glue guns and glue

Plastic containers

Miscellaneous cardboard

Other miscellaneous building items, as desired

1 Stop watch

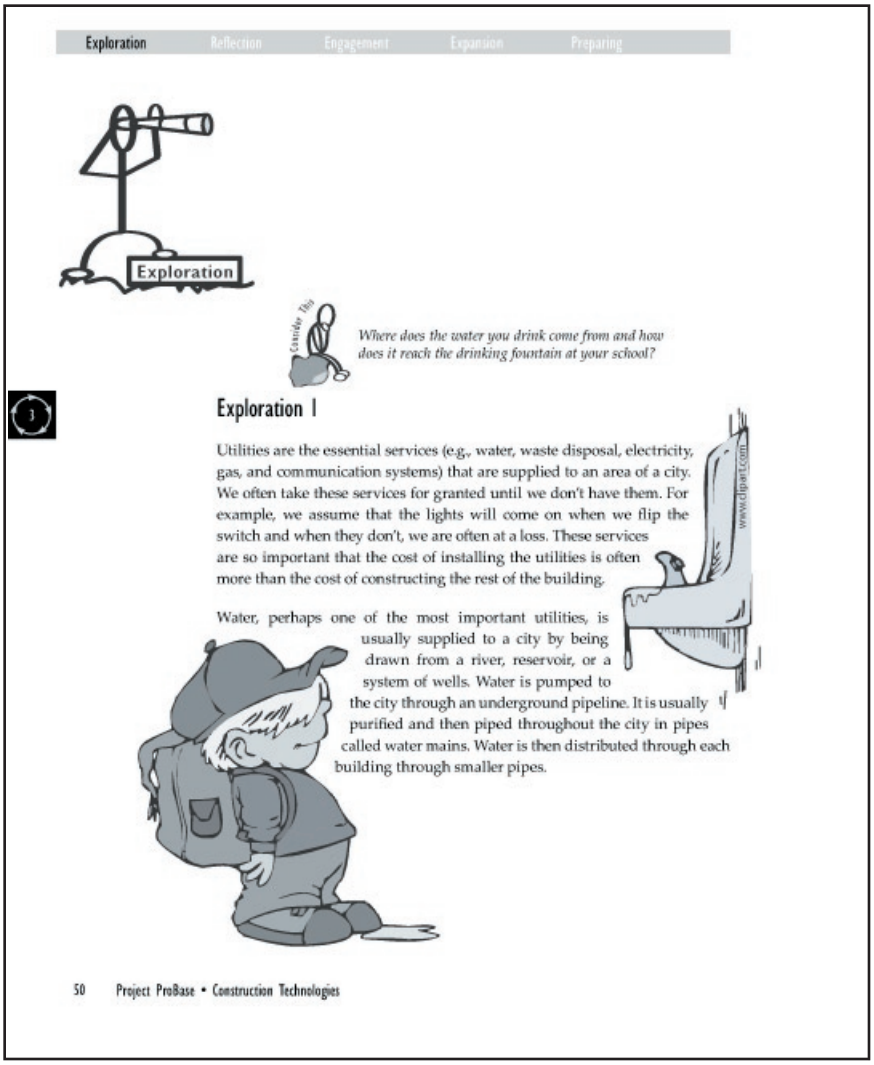
1 Submersible or aquarium pump

25″ of vinyl tubing to fit the pump outlet

Suggested Daily Outline

Estimated number of 50-minute class periods: **6**

Day One	Day Two
Introduction, *Exploration I*	*Exploration I, Reflection I*
Day Three	**Day Four**
Exploration II	*Exploration II, Reflection II*
Day Five	**Day Six**
Engagement	*Engagement,* Preparing for the Challenge



Exploration Reflection Engagement Expansion Preparing

Exploration

Consider This

Where does the water you drink come from and how does it reach the drinking fountain at your school?

Exploration I

Utilities are the essential services (e.g., water, waste disposal, electricity, gas, and communication systems) that are supplied to an area of a city. We often take these services for granted until we don't have them. For example, we assume that the lights will come on when we flip the switch and when they don't, we are often at a loss. These services are so important that the cost of installing the utilities is often more than the cost of constructing the rest of the building.

Water, perhaps one of the most important utilities, is usually supplied to a city by being drawn from a river, reservoir, or a system of wells. Water is pumped to the city through an underground pipeline. It is usually purified and then piped throughout the city in pipes called water mains. Water is then distributed through each building through smaller pipes.

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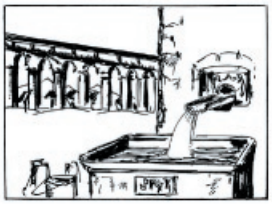
Exploration I

This activity provides the opportunity for students to think about certain types of utility distribution, namely gravity and pressure distribution systems. Student teams will construct an aqueduct system designed to carry water twenty feet up a two-foot grade. After students have timed how long it takes to transport water through their systems, they will compare their results to a pump-fed system. Students should be challenged to work with limited materials and to manage their most important resource: potential energy, as provided by gravity.

Delivering water from far away is not a new idea. Many people have seen pictures of ancient Roman aqueducts. Actually, water systems were developed in Persia, India, Egypt, and other Middle Eastern countries hundreds of years before the Romans used them. However, the ancient Romans are often considered the first to build a complex water infrastructure. Ancient Rome built a system of eleven aqueducts to carry water from as far away as 57 miles. How were the Romans able to develop such a system with limited technology and tools?

The Romans used gravity to carry the water across the miles. When it reached the city, the water went to a series of distribution tanks. From there, the water flowed to public fountains that dispensed water to all citizens. The water ran all the time. Excess water was not stored. Instead, it was used to flush out the sewers. This gravity system was the peak of water technology for many years. Not until around the late 16th century were pumps and pressurized pipe sused to supply water. Many modern cities, like New York, use a combination of the gravity-fed and pump-fed systems. Each has its particular advantages, which you will come to understand in the following activity.



Listed below are several websites that have illustrations of the Archimedes Screw:

www.mcs.drexel.edu/~crorres/Archimedes/Screw/ScrewAnimation.html

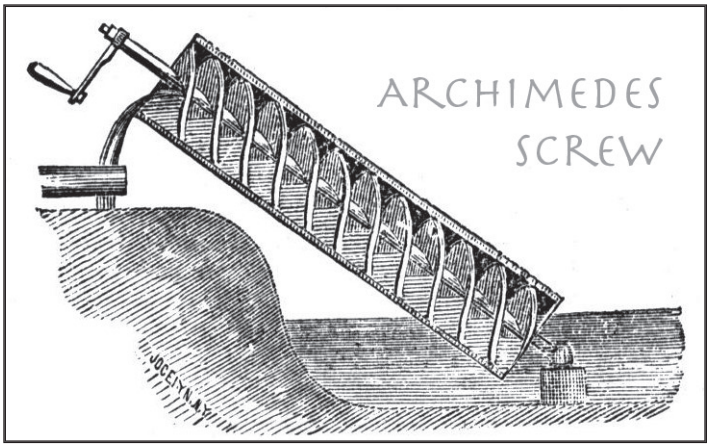
www.animatedsoftware.com/pumpglos/archimed.htm

www.tiscali.co/uk/reference/encyclopedia/hutchinson/m0002929.html

Students will compare their system to a pressure delivery system using a small subermersible pump. This system can be built in advance, or as students are working on their designs.

The class should divide into small teams. Each team will be responsible for building an aqueduct system that meets the design constraints listed in the student guide.

An example of a potential solution is plastic tubing draped over a pile of books and chairs (two feet high). One end will hold the three gallons of water in a bucket and the other end will have an Archimedes Screw-type system and a bucket connected to the tubing.



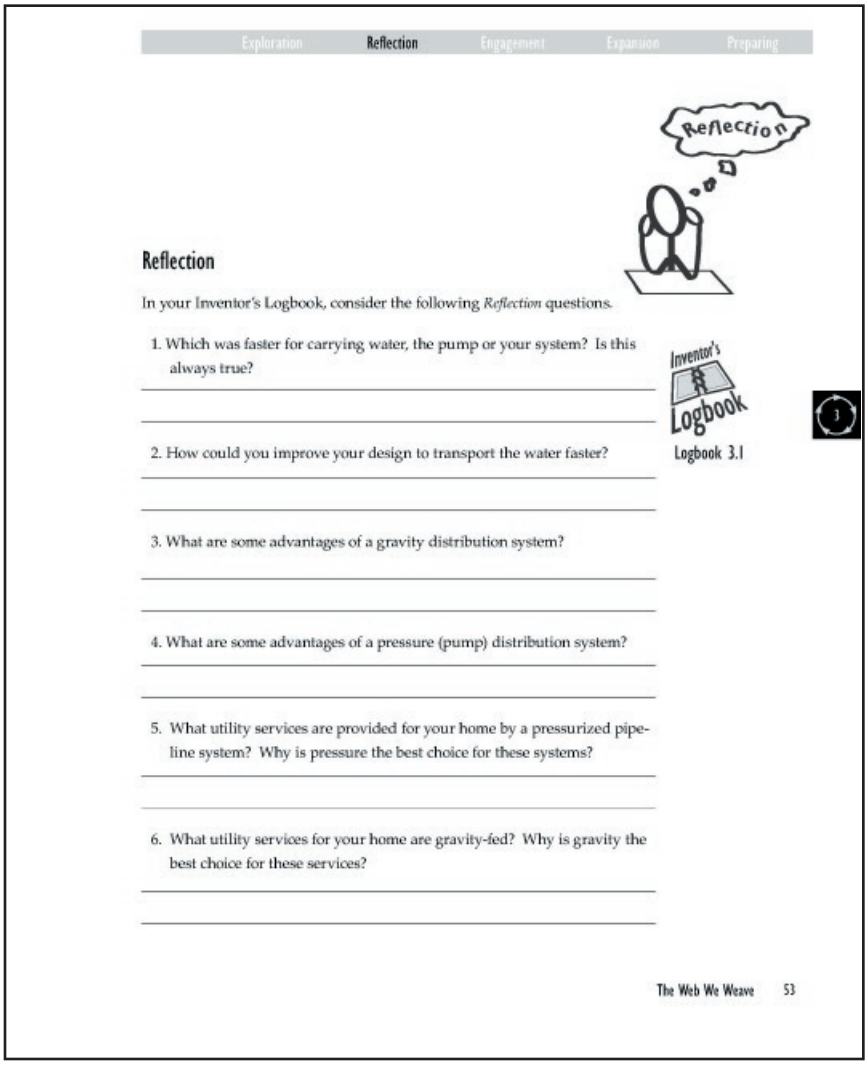
In this activity, you will have the opportunity to analyze the advantages and disadvantages of a gravity water distribution system. You will need to create a system that can carry three gallons of water as quickly as possible over a distance of 20 feet horizontally. The water must also rise a distance of two feet as it moves over the 20-foot horizontal distance

Design parameters

- Your system may not spill or leak any water.
- You have limited materials to use, as provided by your instructor.
- Your system must carry the water faster than a pump distribution system provided by your instructor.
- Water must be delivered into a measuring bucket at the end of the 20 feet. This bucket may not be moved, tilted, or altered.

Once you have created your system, you will need to measure how much time it takes to transport the water. You will then compare your results to a pump system provided by your instructor.

Notes:



Exploration Reflection Engagement Expansion Preparing

Reflection

In your Inventor's Logbook, consider the following *Reflection* questions.

1. Which was faster for carrying water, the pump or your system? Is this always true?

2. How could you improve your design to transport the water faster?

3. What are some advantages of a gravity distribution system?

4. What are some advantages of a pressure (pump) distribution system?

5. What utility services are provided for your home by a pressurized pipeline system? Why is pressure the best choice for these systems?

6. What utility services for your home are gravity-fed? Why is gravity the best choice for these services?

Inventor's Logbook

Logbook 3.1

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Reflection

After completing the *Exploration* activity, students will need to reflect on the knowledge and experience they have acquired to answer the following questions.

1. Which was faster for carrying water, the pump or your system? Is this always true?
   Answers will vary. Variations will depend on the pump size, pipe size, and slope of a gravity system.

2. How could you improve your design to transport the water faster?
   In general, a channel with greater cross-sectional area and greater initial slope will move water faster.

3. What are some advantages of a gravity distribution system?
   Gravity systems are simple, use no energy, and are usually very reliable.

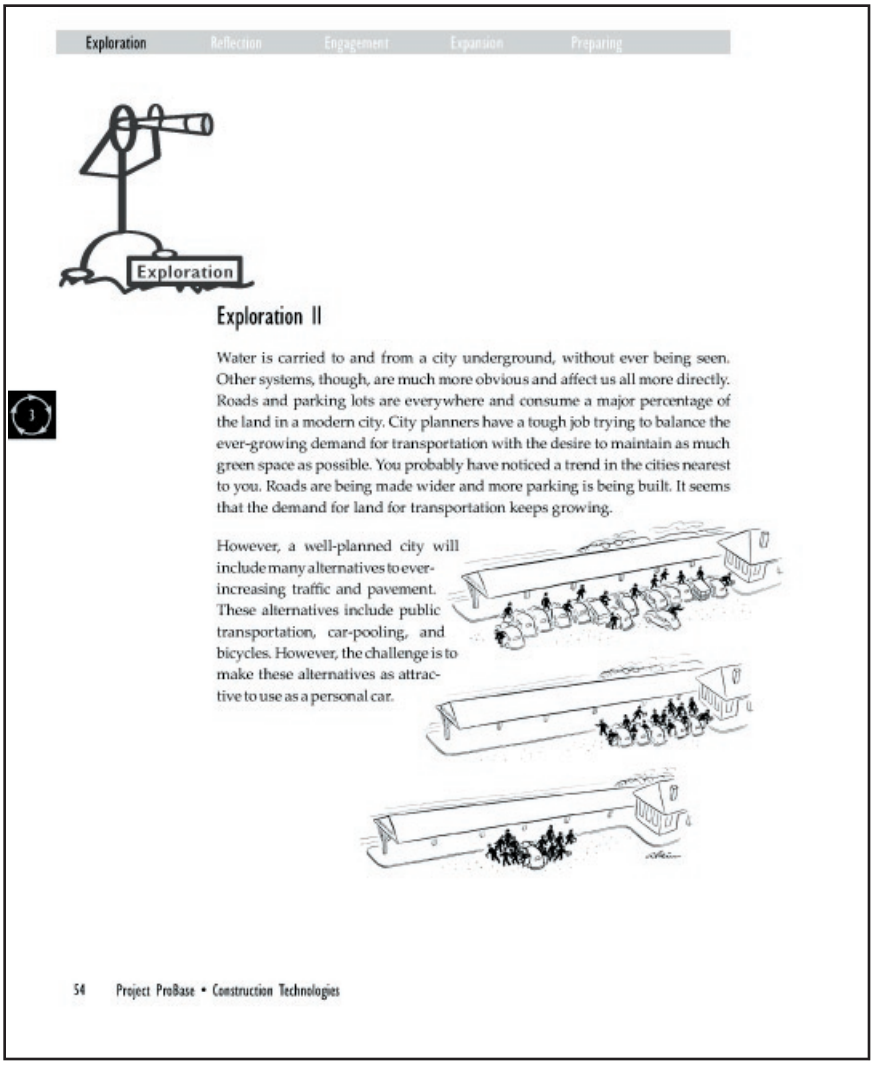
4. What are some advantages of a pressure (pump) distribution system?
   Pumps can deliver fluids uphill, or at higher pressures than gravity systems.

5. What utility services are provided for your home by a pressurized pipeline system? Why is pressure the best choice for these systems?
   Water, natural gas, and steam (for large buildings) are all pressurized. This allows them to be delivered at continuous high pressure, even to the upper floors of a building.

6. What utility services for your home are gravity-fed? Why is gravity the best choice for these services?
   Most sewers are gravity-fed. Storm water systems are also gravity systems. This makes them cheap and reliable. Since the material is carried out of the building instead of into it, upper floors can use gravity too.

Exploration II

In this section, students will look at how parking is designed and managed as a way to learn about land-use issues in city planning. Students will redesign a parking facility to help a school manage its parking problems. Students will need to think through many different factors in order to design a practical and convenient facility.



Exploration Reflection Engagement Expansion Preparing

Exploration

Exploration II

Water is carried to and from a city underground, without ever being seen. Other systems, though, are much more obvious and affect us all more directly. Roads and parking lots are everywhere and consume a major percentage of the land in a modern city. City planners have a tough job trying to balance the ever-growing demand for transportation with the desire to maintain as much green space as possible. You probably have noticed a trend in the cities nearest to you. Roads are being made wider and more parking is being built. It seems that the demand for land for transportation keeps growing.

However, a well-planned city will include many alternatives to ever-increasing traffic and pavement. These alternatives include public transportation, car-pooling, and bicycles. However, the challenge is to make these alternatives as attractive to use as a personal car.

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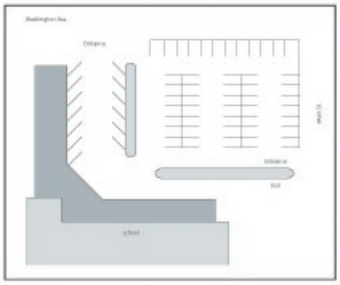
This activity will be of little benefit if students merely sketch some plans based on speculation. To get the most out of this activity, students will need to work with a high degree of accuracy and consider many different sources of data. Land-use plans should be drawn to scale and accurate dimensions should be used for road widths, parking space sizes, and other key dimensions. Much of this information will need to be gathered by the students themselves, either from reference sources or from actual measurements. Students will also need data about the percentage of students who drive, ride with others, take public transportation, bike, etc. to school. This data might be gathered by a school or class survey.

Scenario

A school in your state, Lincoln High, has encountered this problem first-hand. The school has just built a new facility on the edge of town. The new facility includes large classrooms, athletic fields, and parking for students and faculty. However, the student parking lot is constantly overflowing and many students park on the streets. Now the residents nearby are complaining that they can't park their cars as they used to. On top of these problems, traffic congestion has led to students being late to class and even a few accidents. It seems the new school parking system has created a lot of animosity in the town.



The city council and the school board have formed a committee to resolve the problem. As part of the committee, your job is to help find a way to reduce traffic congestion and overflow parking. Your specific task is to:

1. Find a way to keep all student parking on school grounds.
2. Reduce morning and afternoon traffic by at least ten percent.
3. Encourage alternative forms of transportation.

You may recommend any city laws or school policies that you desire. The committee also has a small budget, enough for construction of 1,600 square feet of road or parking lot.

Teaching Tips

You could personalize this activity by incorporating your school's parking lot layout and school data (e.g., number of faculty and staff, size of spaces). You could also include an examination of ADA requirements.

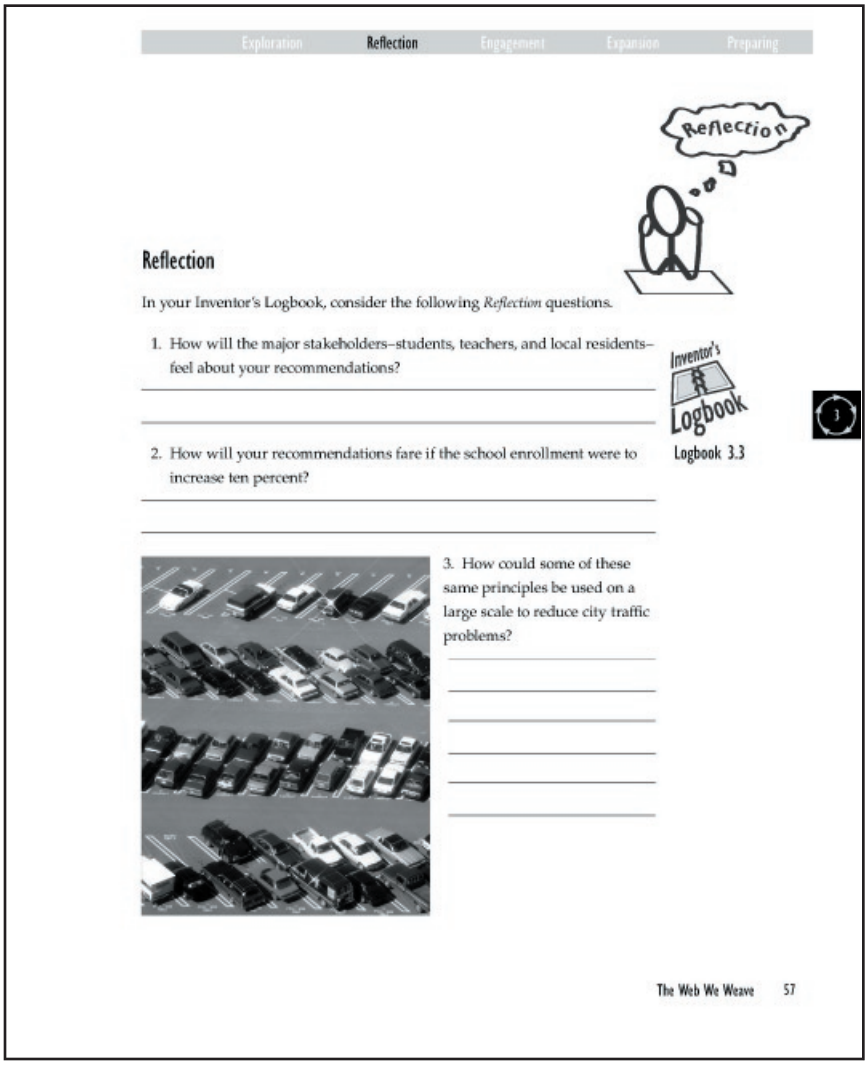
In your group, write and sketch some ideas for achieving the goals listed above. Then, select the best ones to put together into a plan. In the space provided, list any laws and policies that you recommend, along with a scale drawing of any construction changes that you recommend.

Include your responses below.

Inventor's Logbook

Logbook 3.2

Notes:



Exploration Reflection Engagement Expansion Preparing

Reflection

In your Inventor's Logbook, consider the following *Reflection* questions.

1. How will the major stakeholders–students, teachers, and local residents–feel about your recommendations?

2. How will your recommendations fare if the school enrollment were to increase ten percent?

3. How could some of these same principles be used on a large scale to reduce city traffic problems?

Inventor's Logbook

Logbook 3.3

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Reflection

After completing the *Exploration* activity, students will need to reflect on the knowledge and experience they have acquired to answer the following questions.

1. How will the major stakeholders–students, teachers, and local residents–feel about your recommendations?
   Answers will vary depending on how students accomplished the traffic and parking reductions. Depending on the proposal, students or residents may be quite unhappy with the changes.

2. How will your recommendations fare if the school enrollment were to increase ten percent?
   Answers will again vary. The question is designed to get students thinking about normal variations that must be expected in any long-term plan.

3. How could some of these same principles be used on a large scale to reduce city traffic problems?
   Students and teachers aren't the only ones who can be encouraged to find alternative forms of transportation. Park-and-ride lots for public transportation, carpool lanes on freeways, restricted parking areas, and other means can all be used to reduce congestion caused by automobiles.

Engagement

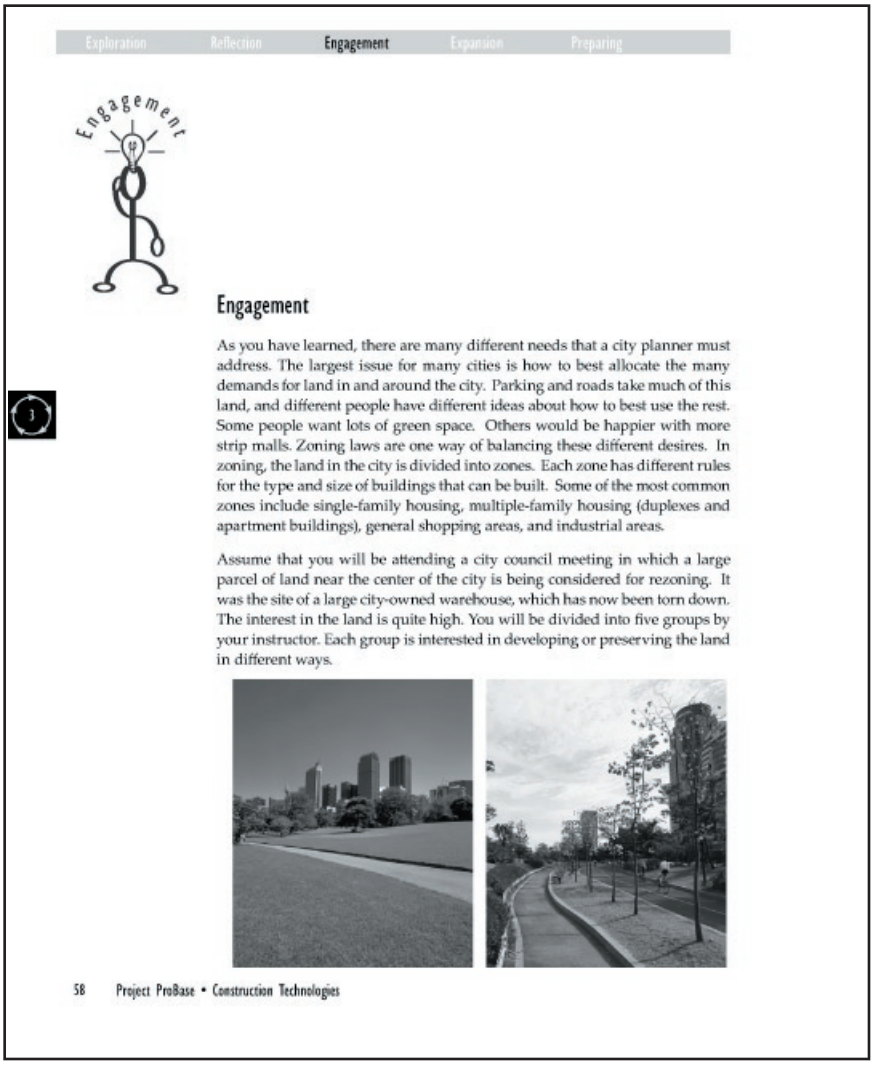
Students will need to be divided into five teams during the *Engagement* phase of this learning cycle to prepare a proposal for developing a piece of land. Each team will need to be assigned to represent the interest of one of the groups listed below. Each group is interested in developing or preserving the land in a different way.

The five groups are:

- An organization of builders wanting to primarily build single-family homes.
- A group of builders interested in constructing multiple apartment buildings, along with a shopping/convenience mall.
- A developer wanting to construct a large-scale shopping area.
- A developer interested in turning the land into an industrial park attracting both light and heavy industrial facilities.
- An environmental advocacy organization asking the city to keep the land and develop a portion into some type of recreational facility or park.

Teaching Tips

You may want to assign zoning areas on the lot to teams.



Exploration Reflection Engagement Expansion Preparing

Engagement

Engagement

As you have learned, there are many different needs that a city planner must address. The largest issue for many cities is how to best allocate the many demands for land in and around the city. Parking and roads take much of this land, and different people have different ideas about how to best use the rest. Some people want lots of green space. Others would be happier with more strip malls. Zoning laws are one way of balancing these different desires. In zoning, the land in the city is divided into zones. Each zone has different rules for the type and size of buildings that can be built. Some of the most common zones include single-family housing, multiple-family housing (duplexes and apartment buildings), general shopping areas, and industrial areas.

Assume that you will be attending a city council meeting in which a large parcel of land near the center of the city is being considered for rezoning. It was the site of a large city-owned warehouse, which has now been torn down. The interest in the land is quite high. You will be divided into five groups by your instructor. Each group is interested in developing or preserving the land in different ways.

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Conventional Minimum Parking Ratios (Source: ITE, 1987; Smith, 1984; and Wells, 1994)		
Land Use	**Parking Ratio**	**Actual Average Parking Demand**
Single family homes	2 spaces per unit	1.11 spaces per unit
Shopping center	5 spaces per 1000 sq feet GFA	3.97 per 1000 sq feet GFA
Industrial	1 space per 1000 sq feet GFA	1.48 per 1000 sq feet GFA
GFA = Gross Floor Area of a building without storage or utility spaces		

If time allows, you may decide to have the students vote for the best proposal. And then, in teams of four or five, each team will build a scale model of how they interpret the proposal.

Specific Interest Groups

- An organization of builders wanting to primarily build single-family homes.
- A group of builders interested in constructing multiple apartment buildings, along with a shopping/convenience mall.
- A developer wanting to construct a large-scale shopping area.
- A developer interested in turning the land into an industrial park, attracting both light and heavy industrial facilities.
- An environmental advocacy organization asking the city to keep the land and develop a portion into some type of recreational facility or park.

The city has six zoning classifications:

Zone	Requirements
R1	Single-family homes only. No business establishments are permitted.
R2	Mixed single-family and multi-family buildings. Apartments can make up no more than 66% of all land area. No business establishments are permitted.
R3	Multi-family buildings. Limited business uses are allowed, such as a café or convenience store on the ground floor of an apartment building.
C1	Retail and office buildings. No residences are permitted. No manufacturing or related industries are permitted.
C2	Retail, office, and light industrial buildings. No heavy truck traffic is allowed on streets in this district.
G	Government-owned land. Uses include schools, public buildings, and parks. No residences or commercial buildings are permitted.

The activity ties into the previous one by asking students to specifically include plans for parking in their proposal. On the previous page is a graph illustrating conventional parking ratios for a few different types of developments. Students should research their development's parking needs and estimate answers for thequestions on page 59 of the Student Guide . Some answers may be educated guesses, but should be within reason.

Each group will need to conduct research based on their needs and choose a zoning classification to recommend, along with a rationale stating why they chose that classification. A set of six zoning classifications are listed in the Student Guide. If desired, the class could substitute actual local zoning classifications. Each group will need to prepare a presentation outlining its proposal and rationale, including a description of exactly how they would develop the land.

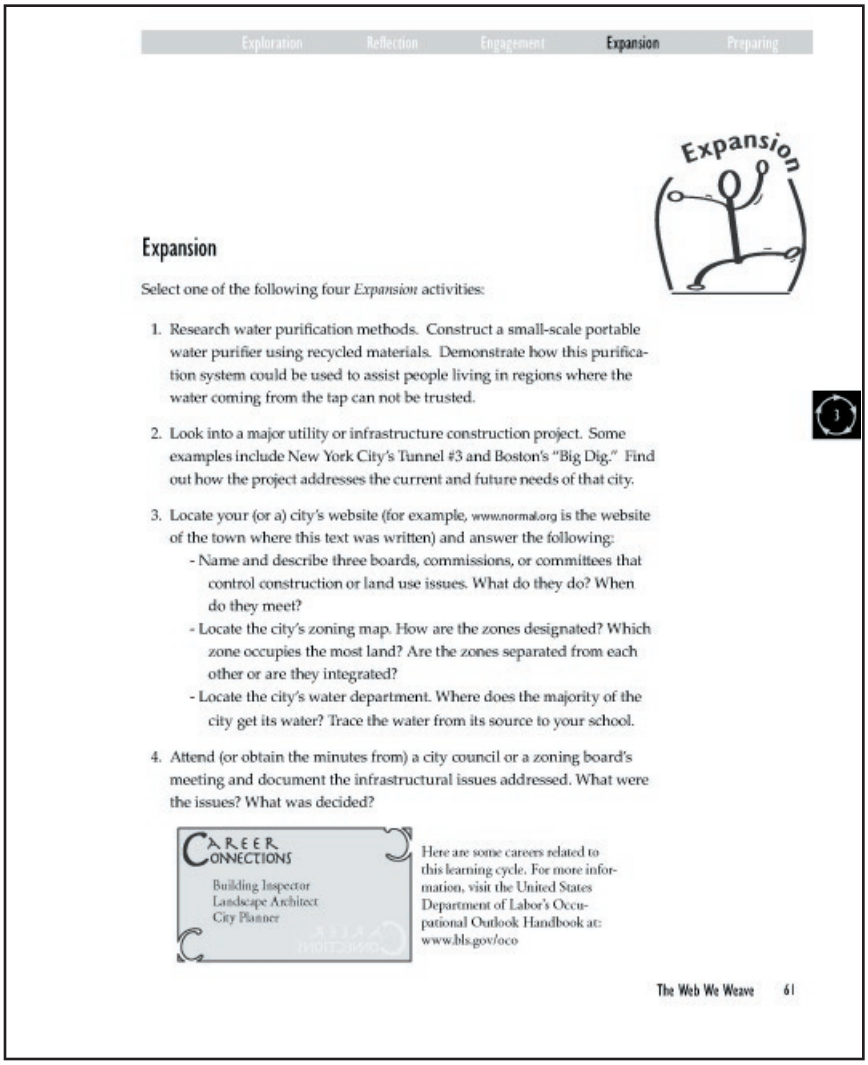
Your group will conduct research and prepare a presentation outlining why your suggested zoning should be adopted for this piece of land. Presentations should describe how your development will address the following needs:

1. Economy - cost and appropriateness of your development to the piece of land described.
2. Targeted customers or people using the development.
3. Functionality - how the targeted customers or people using the land will interact with the development and the land
4. Ease of installation and use of land - how much green space will be preserved?
5. Appearance - what will the development look like in regards to the land?
6. What parking will be needed by your development and how will it be provided? Your presentation should include specific calculations of the number of spaces needed, based on research you have done, and how much area will be needed for those parking spaces.
7. Each group will present a five- to ten-minute presentation covering the specified requirements.

As a class discuss the following:

1. Which development will best utilize the land to account for income? Preserving green space? Parking?
2. Which of the above criteria do you think cities usually consider more than others?

Notes:



Exploration Reflection Engagement Expansion Preparing

Expansion

Expansion

Select one of the following four *Expansion* activities:

1. Research water purification methods. Construct a small-scale portable water purifier using recycled materials. Demonstrate how this purification system could be used to assist people living in regions where the water coming from the tap can not be trusted.
2. Look into a major utility or infrastructure construction project. Some examples include New York City's Tunnel #3 and Boston's "Big Dig." Find out how the project addresses the current and future needs of that city.
3. Locate your (or a) city's website (for example, www.normal.org is the website of the town where this text was written) and answer the following:
   - Name and describe three boards, commissions, or committees that control construction or land use issues. What do they do? When do they meet?
   - Locate the city's zoning map. How are the zones designated? Which zone occupies the most land? Are the zones separated from each other or are they integrated?
   - Locate the city's water department. Where does the majority of the city get its water? Trace the water from its source to your school.
4. Attend (or obtain the minutes from) a city council or a zoning board's meeting and document the infrastructural issues addressed. What were the issues? What was decided?

Career Connections

Building Inspector
Landscape Architect
City Planner

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

The Web We Weave 61

Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explored in this learning cycle.

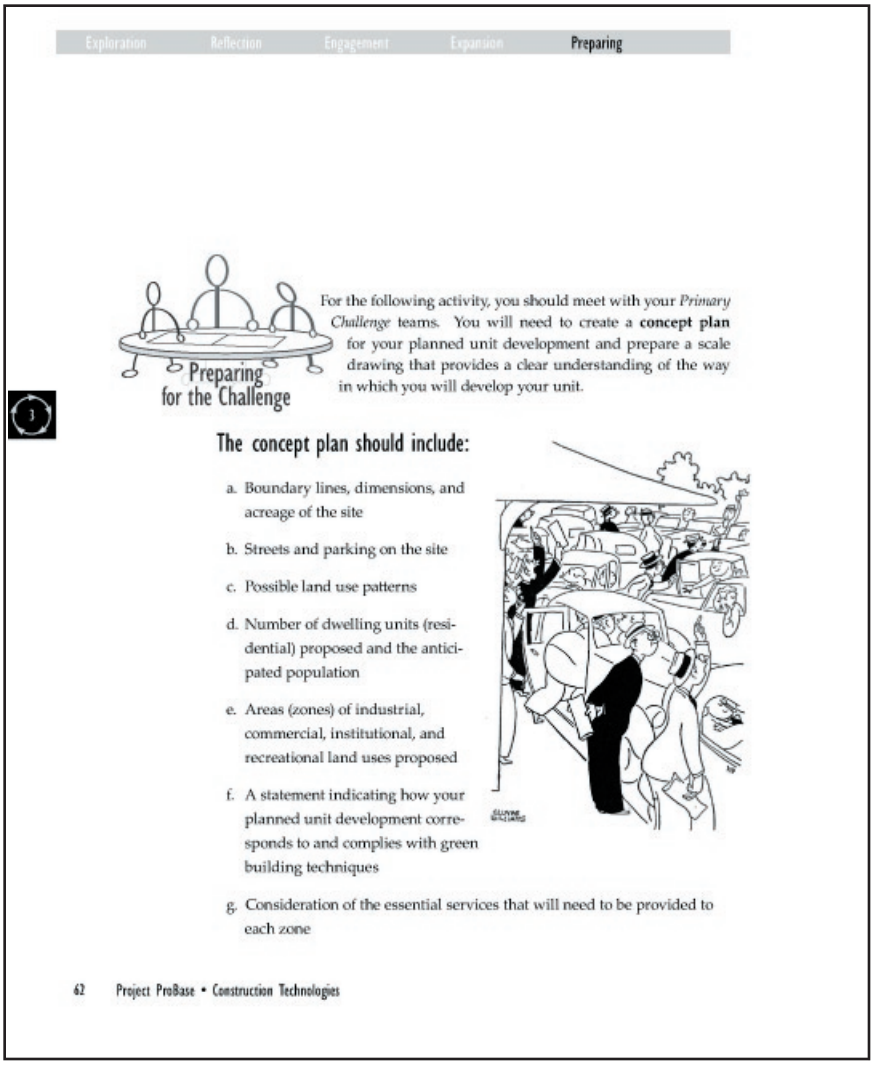
1. Research water purification methods. Construct a small-scale portable water purifier using recycled materials. Demonstrate how this purification system could be used to assist people living in regions where the water coming from the tap can not be trusted.
2. Look into a major utility or infrastructure construction project. Some examples include New York City's Tunnel #3 and Boston's "Big Dig." Find out how the project addresses the current and future needs of that city.
3. Locate your (or a) city's website (for example, www.normal.org is the website of the town where this text was written) and answer the following:
   - Name and describe three boards, commissions, or committees that control construction or land use issues. What do they do? When do they meet?
   - Locate the city's zoning map. How are the zones designated? Which zone occupies the most land? Are the zones separated from each other or are they integrated?
   - Locate the city's water department. Where does the majority of the city get its water? Trace the water from its source to your school.
4. Attend (or obtain the minutes from) a city council or a zoning board's meeting and document the infrastructural issues addressed. What were the issues? What was decided?

Preparing for the Challenge

Students will need to work in their *Primary Challenge* teams to create a concept plan outlining their planned unit development. The concept plan will provide an opportunity for students to design their unit on paper and think through the various elements. A scale drawing should also be prepared during this time. A suggested scale is 1:500 for a 12-inch square drawing.

The Concept Plan should include:

a. Boundary lines, dimensions, and acreage of the site
b. Streets and parking on the site
c. Possible land use patterns
d. Number of dwelling units (residential) proposed and anticipated population
e. Areas (zones) of industrial, commercial, institutional, and recreational land uses proposed
f. A statement indicating how the planned unit development corresponds to, and complies with, green building techniques
g. Utilities-consideration of the essential services that will need to be provided to each zone



Exploration Reflection Engagement Expansion **Preparing**

Preparing for the Challenge

For the following activity, you should meet with your *Primary Challenge* teams. You will need to create a **concept plan** for your planned unit development and prepare a scale drawing that provides a clear understanding of the way in which you will develop your unit.

The concept plan should include:

a. Boundary lines, dimensions, and acreage of the site
b. Streets and parking on the site
c. Possible land use patterns
d. Number of dwelling units (residential) proposed and the anticipated population
e. Areas (zones) of industrial, commercial, institutional, and recreational land uses proposed
f. A statement indicating how your planned unit development corresponds to and complies with green building techniques
g. Consideration of the essential services that will need to be provided to each zone

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Student Assessment

An assessment rubric has been written for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your needs.

The Web We Weave

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Exploration I Aqueduct System with Purifier	Successfully created an aqueduct system and purifier; followed all guidelines.	Successfully created an aqueduct system and purifier; met most of the guidelines.	Encountered difficulty in creating aqueduct system and purifier; did not meet all guidelines.	Did not successfully create an aqueduct system and/or purifier; did not meet guidelines.	
Exploration II School Parking Facility	Made compelling recommendations; met all requirements.	Made logical recommendations; met most of the requirements.	Encountered difficulty; did not meet all of the requirements.	Did not successfully finish project; met few of the requirements.	
Engagement Zoning Debate	Successfully prepared presentation; worked extremely well within group; met all specifications.	Successfully prepared presentation; worked well within group; met most of the specifications.	Encountered difficulty preparing presentation; experienced difficulty working in group; did not meet all specifications.	Did not successfully meet requirements; did not work well in group; met few specifications.	
Inventor's Logbook Entries	Completely answered all entries.	Completely answered most of the entries.	Answered few entries completely.	Did not answer entries.	
				Total	

Learning Cycle Four

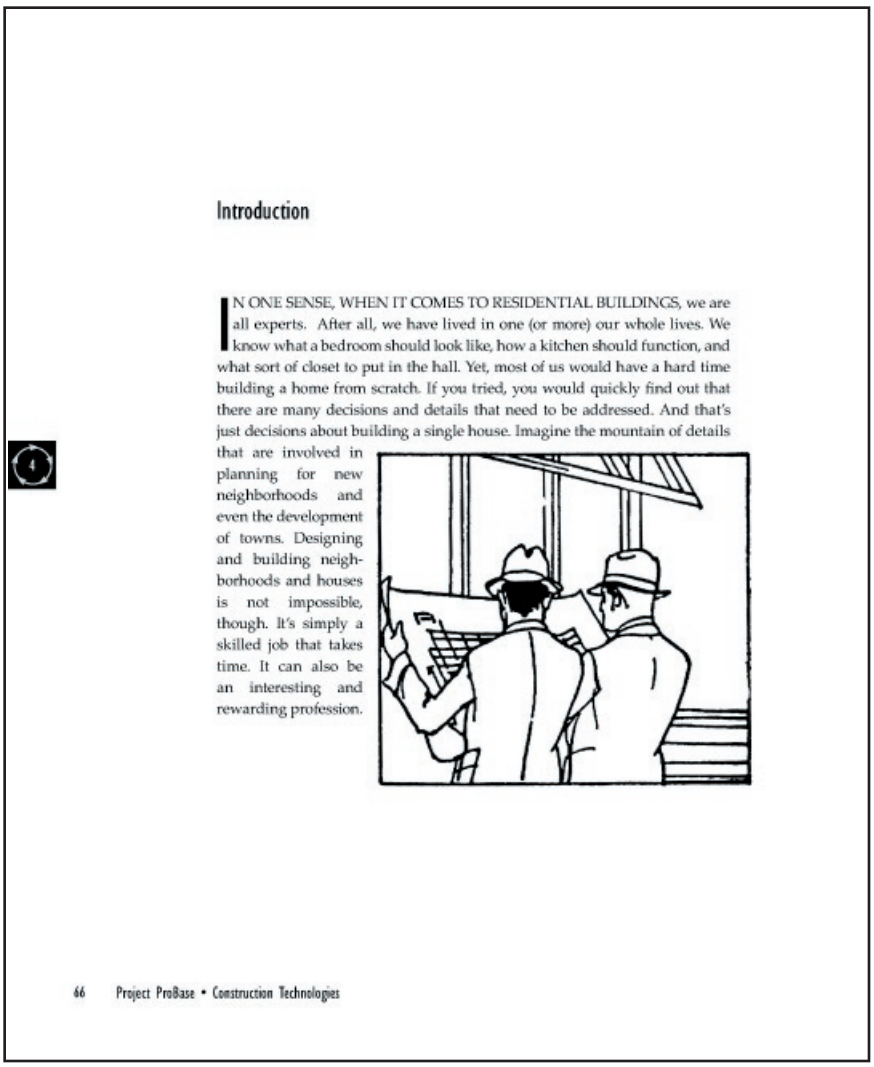
There's No Place Like Home

4

There's No Place Like Home

Introduction

In this learning cycle, students will learn the specifics of how modern North American homes are designed and built. The *Exploration* section covers basic steps in floor planning, including a brief introduction to standard dimensions and code requirements. Students will design and draw a small apartment unit using techniques they learn in this unit. The *Engagement* section covers platform framing techniques. Students research building materials in a standard wall section, and then build a full-size section. Finally, students work towards the *Primary Challenge* by designing and completing drawings of floor plans for the planned unit development.



Introduction

IN ONE SENSE, WHEN IT COMES TO RESIDENTIAL BUILDINGS, we are all experts. After all, we have lived in one (or more) our whole lives. We know what a bedroom should look like, how a kitchen should function, and what sort of closet to put in the hall. Yet, most of us would have a hard time building a home from scratch. If you tried, you would quickly find out that there are many decisions and details that need to be addressed. And that's just decisions about building a single house. Imagine the mountain of details that are involved in planning for new neighborhoods and even the development of towns. Designing and building neighborhoods and houses is not impossible, though. It's simply a skilled job that takes time. It can also be an interesting and rewarding profession.

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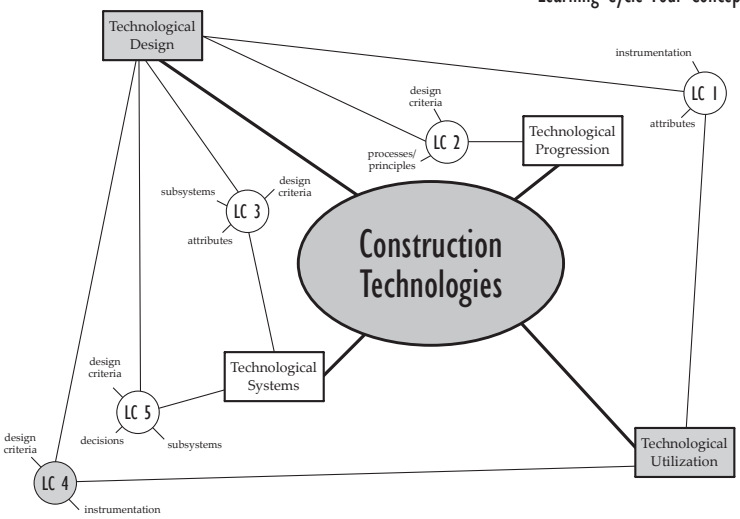
Objectives and Essential Questions

After completing this learning cycle, students will be able to:

1. Employ common techniques for residential housing design.

Essential Question 7c: What design criteria are typically considered when developing new technologies and how do these influence the final product/system design?

ConstructionTechnologies
Learning Cycle Four Concept Map



In this learning cycle, you will learn the specifics of how homes are designed and built. First, you will learn how architects make plans–how they lay out rooms and decide on the locations of walls. You will design a small space of your own using these techniques. Then, you will learn how builders actually assemble wood, nails, concrete, and other materials into a structure. You will build a section of a full-size building. Finally, you will apply what you have learned to the *Primary Challenge* and determine the floor plans for your planned unit development.

Objectives

After completing this learning cycle, you will be able to:

1. Employ common techniques for residential housing design.
2. Sketch elementary construction details such as foundations, framing, roofing, and sheathing.
3. Demonstrate appropriate residential building techniques.

There's No Place Like Home 67

2. Sketch elementary construction details such as foundations, framing, roofing, and sheathing.

Essential Question 9d: How is technological instrumentation used to measure, calculate, manipulate, and predict the actions of technological devices and systems?

3. Demonstrate appropriate residential building techniques.

Essential Question 9d: How is technological instrumentations used to measure, calculate, manipulate, and predict the actions of technological devices and systems?

Facility Requirements

The *Engagement* activity revolves around the construction of a full-scale section of a frame building. Ideally, the class will be able to complete this activity in a room with a high ceiling or in a sheltered outside location. Approximately fifteen feet from floor to ceiling will be required, depending on foundation depth and the roof pitch used in the wall section. If this is unworkable, the wall section may be modified to use walls that are less than the standard eight feet in height. There are no special requirements for the *Exploration* and *Preparing for the Challenge* activities.

Equipment

If a life-size option is used, these items are suggested. Other tools may be used as appropriate. The quantities listed below are approximate.

(8) Hammers

(8) Tape measures

(4) Quick squares

Rafter square

(4) Crosscut saws

Circular saw

(3) Mortar trowels

Mixing bucket

Metal hand shears

Electric drill with ½″ and 1″ bits

Propane torch

Wheel barrows

Hose-outside access

Hoe/shovel

Protective floor covering

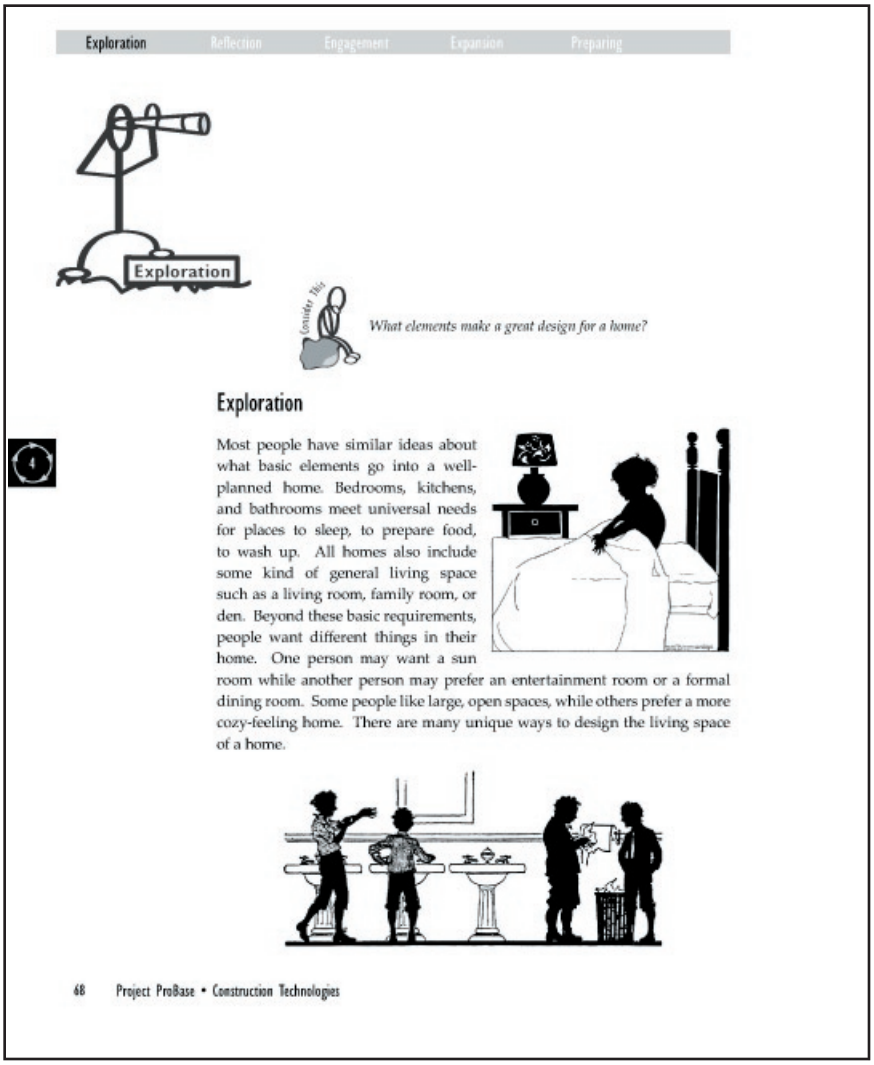
Equipment/Materials

The quantities listed below are approximate.

Item	Size	Qty
2x4	8 ft	6
2x4, Pressure-treated	8 ft	1
1x6 Fascia	4+ ft	1
2x10	8 ft	8
2x12	8 ft	5
½″ OSB or plywood	4x8	1
¾″ OSB or plywood	4x8	2
Concrete blocks	Full	20
Mortar	50 lb	1
10d nails	~	5 lb
16d nails	~	5 lb
Anchor bolts	8 in	3
Metal soffit	~	4 ft.
Roofing felt	~	20 ft^2
Shingles (1 pkg)	~	20 ft^2
NM electrical cable	14-2	25 ft.
Electrical outlet	Duplex	1
Electrical box	1-gang	1
Cable clips	14-2	1 box
Copper tubing, type M	½″	10 ft
Copper elbows	½″	4
Water stops, solder fitting	½″	2
Solder	~	1 lb
Flux	~	8 oz.
Pipe fasteners	½″	10

Suggested Daily Outline

Estimated number of 50-minute class periods: **10**



Exploration Reflection Engagement Expansion Preparing

Exploration

Consider This

What elements make a great design for a home?

Exploration

Most people have similar ideas about what basic elements go into a well-planned home. Bedrooms, kitchens, and bathrooms meet universal needs for places to sleep, to prepare food, to wash up. All homes also include some kind of general living space such as a living room, family room, or den. Beyond these basic requirements, people want different things in their home. One person may want a sun room while another person may prefer an entertainment room or a formal dining room. Some people like large, open spaces, while others prefer a more cozy-feeling home. There are many unique ways to design the living space of a home.

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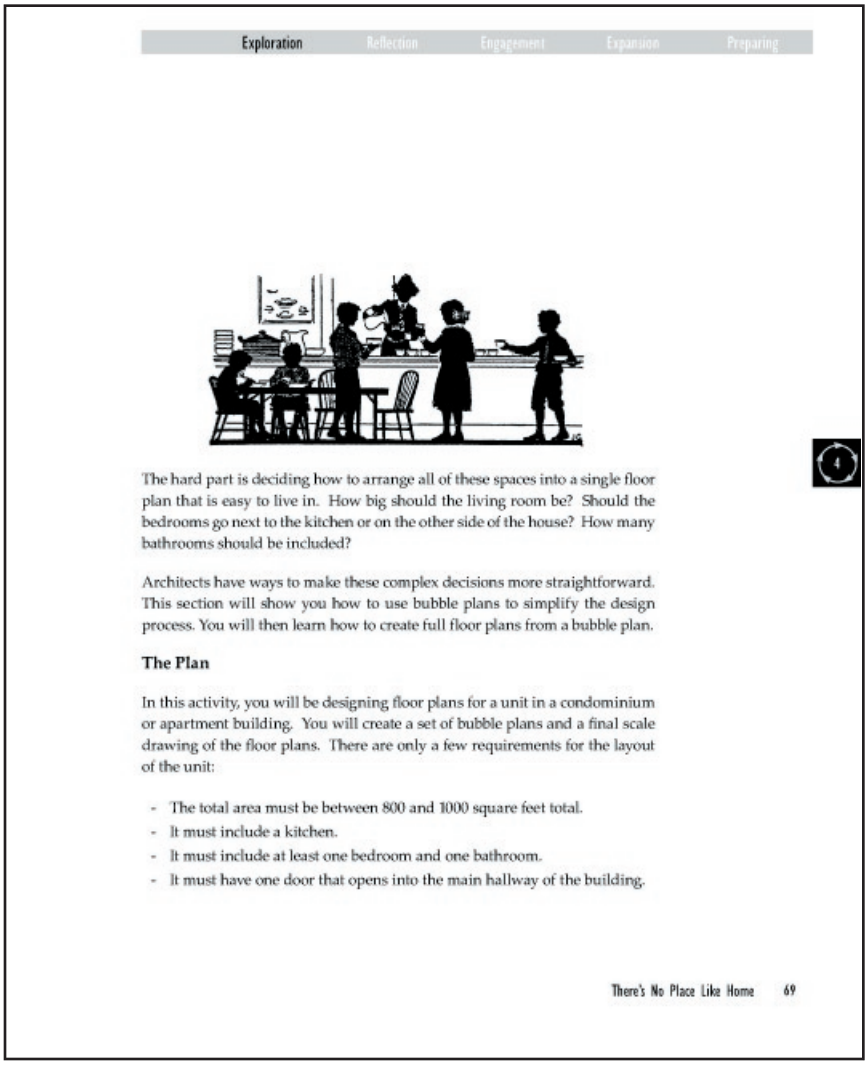
Day One	Day Two	Day Three	Day Four
Introduction, *Exploration*	*Exploration*	*Reflection, Engagement*	*Engagement*
Day Five	**Day Six**	**Day Seven**	**Day Eight**
Engagement	*Engagement*	*Engagement*	*Engagement*
Day Nine	**Day Ten**		
Engagement	*Preparing for the Challenge*		



Exploration Reflection Engagement Expansion Preparing

The hard part is deciding how to arrange all of these spaces into a single floor plan that is easy to live in. How big should the living room be? Should the bedrooms go next to the kitchen or on the other side of the house? How many bathrooms should be included?

Architects have ways to make these complex decisions more straightforward. This section will show you how to use bubble plans to simplify the design process. You will then learn how to create full floor plans from a bubble plan.

The Plan

In this activity, you will be designing floor plans for a unit in a condominium or apartment building. You will create a set of bubble plans and a final scale drawing of the floor plans. There are only a few requirements for the layout of the unit:

- The total area must be between 800 and 1000 square feet total.
- It must include a kitchen.
- It must include at least one bedroom and one bathroom.
- It must have one door that opens into the main hallway of the building.

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Students are asked to design a floor plan for a unit in an apartment or condominium. A few general requirements are listed in the Student Guide, such as a total size of 800 to 1,000 square feet. The requirements are left intentionally vague, though, to allow students to make the major design decisions themselves. Some students might ask for more guidance on what rooms to include in their floor plan, and how to arrange them. While some guidance is appropriate, students should be challenged to make their own design decisions based on careful thought.

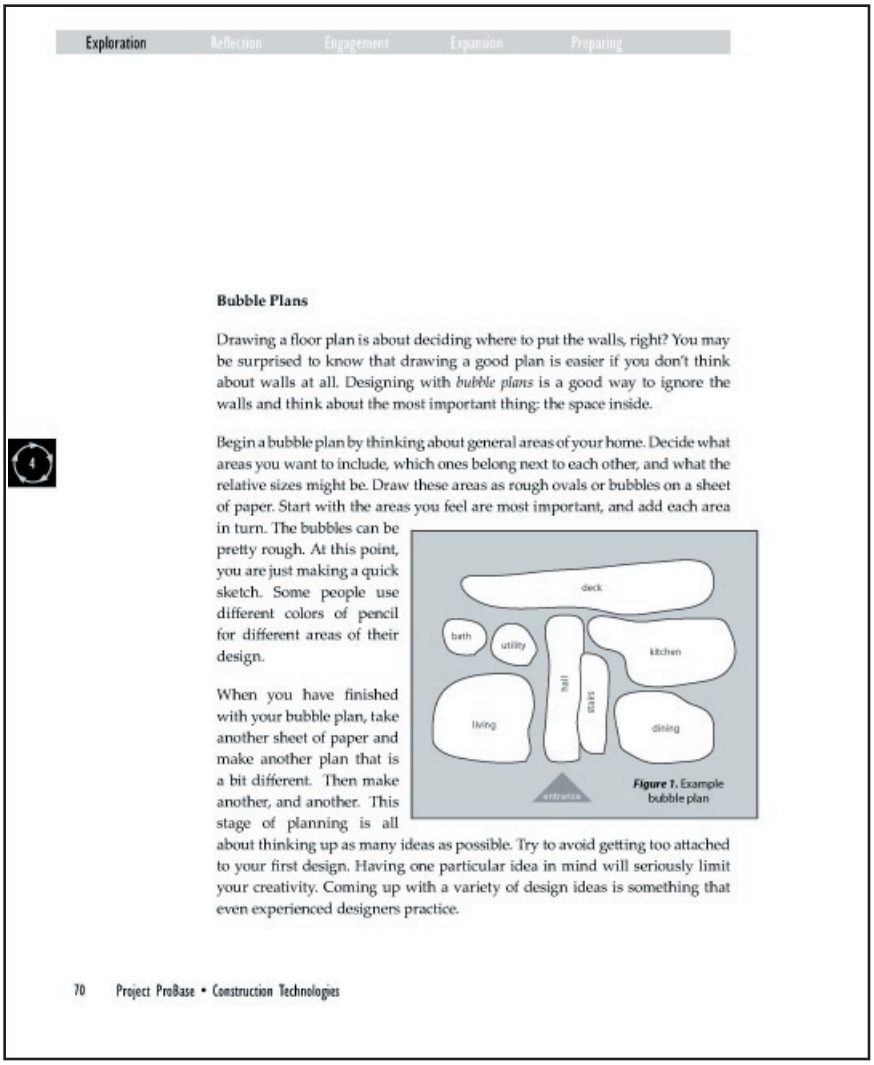
Exploration

The *Exploration* activity teaches students basic techniques for effective floor planning. This is not intended to be a full introduction to residential design, and items such as loads, spans, and other engineering calculations are intentionally not covered. However, standard material sizes and code requirements are briefly discussed.

Safety

Students should wear gloves when handling pressure-treated wood. If they make any cuts, a dust mask should also be worn. After working with pressure-treated lumber, have students wash any skin that has come in contact with the wood or dust.

The activity begins with an introduction to bubble plans. The Student Guide contains instructions on how to complete a basic bubble plan. Students should be encouraged (or required) to complete a number if iterations of their designs in bubble form–eight to ten sketches is not excessive. Recycled paper or the back of used paper is fine for these types of sketches.



Exploration Reflection Engagement Expansion Preparing

Bubble Plans

Drawing a floor plan is about deciding where to put the walls, right? You may be surprised to know that drawing a good plan is easier if you don't think about walls at all. Designing with *bubble plans* is a good way to ignore the walls and think about the most important thing: the space inside.

Begin a bubble plan by thinking about general areas of your home. Decide what areas you want to include, which ones belong next to each other, and what the relative sizes might be. Draw these areas as rough ovals or bubbles on a sheet of paper. Start with the areas you feel are most important, and add each area in turn. The bubbles can be pretty rough. At this point, you are just making a quick sketch. Some people use different colors of pencil for different areas of their design.

When you have finished with your bubble plan, take another sheet of paper and make another plan that is a bit different. Then make another, and another. This stage of planning is all about thinking up as many ideas as possible. Try to avoid getting too attached to your first design. Having one particular idea in mind will seriously limit your creativity. Coming up with a variety of design ideas is something that even experienced designers practice.

Figure 1. Example bubble plan

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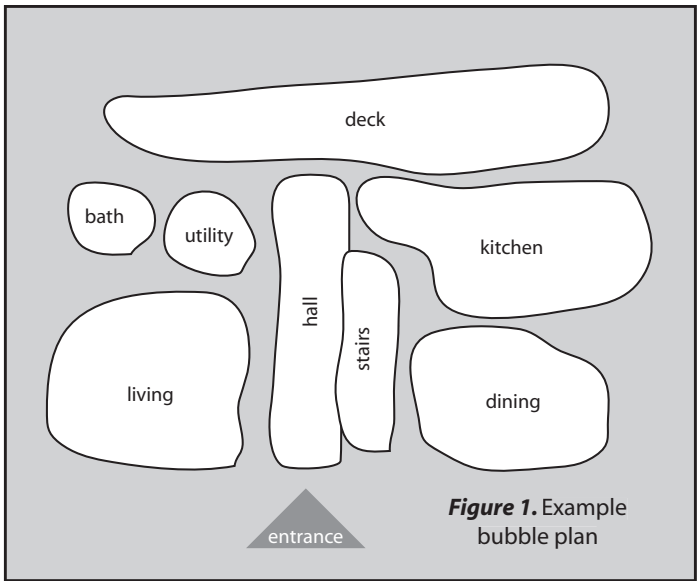
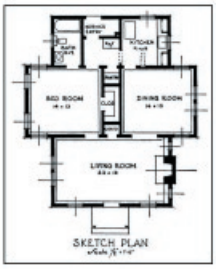


Figure 1. Example bubble plan

Once you have generated a variety of ideas, choose two or three of the sketches that you like best. Think about how a person would move between the bubbles. Draw arrows on each sketch to show the most common paths that people would take. Then, start closing in the bubbles by drawing dark lines where you might want walls. Don't be too quick to close everything in–leave lots of room for doors, windows, and other openings. Leave these openings as light lines. You may want to make copies of one of the sketches and try different ways of closing in the bubbles.

Floor Plans



Once you have a bubble plan that you are happy with, you can start drawing full floor plans. Don't rush into this step, though! A good bubble plan makes floor planning a breeze. Floor plans are much harder to do if you don't have a good sketch in hand to start from.

Your bubble plan is full of ovals. For practical reasons, most real rooms are rectangular. To make a full floor plan, then, you need to square off your bubbles to make practical rooms. Make one "in-between" sketch this way. Sketch light rectangles that are the same general size and proportion as your bubbles. Then darken the lines that you want to close in for walls.

In addition to rectangular rooms, real floor plans have to allow for two other important practical limitations:

1. Building materials come in standard sizes.
2. Building codes require minimum sizes for certain spaces.

Students will then begin refining their designs by selecting a few top choices and adding walls, then creating a rough rectangular sketch. This is followed by conversion to full floor plans. At this point, standard sizes of materials and rooms may be covered in as much depth as is desired. Students should then be given time to complete and turn in a presentation-quality floor plan of their chosen design.

Drawing a realistic plan means adjusting your room sizes to account for standard size materials and building code rules. The tables on this page show some of the typical limitations on materials and sizes. You can find other standard sizes in a builder's handbook.

Item	Standard Size
Inside door	30"
Outside door	32"
Bathtub	30" x 60"
Kitchen counters	24" deep, even multiples of 3" wide
Plywood & Drywall	48" x 96"
Lumber	Even multiples of 24" long

Notice the values for plywood, drywall, and lumber. All the standard sizes for these items are even multiples of 24 inches, or 2 feet. For this reason, it is good design practice to make room sizes in even multiples of two feet as well. For example, make a bedroom 10 feet by 10 feet instead of 9 feet by 11 feet. Sometimes this isn't possible, and other sizes are certainly acceptable. The two-foot rule simply helps builders to complete the structure more quickly and economically and with less waste.

On the right is a table outlining typical building codes for the minimum size of rooms and other spaces. Take these room sizes into account as you adjust the dimensions of your plan. Your instructor will give you more instructions on the final format of the floor plans and will tell you what type of paper to use.

Room	Typical minimum size allowed by building codes
Main room	150 square feet
Kitchen	50 square feet
All other rooms	70 square feet
Stairways	3 feet wide
Hallway	3 feet wide
All rooms must have at least one window	

Item	Standard Size
Inside door	30"
Outside door	32"
Bathtub	30" x 60"
Kitchen counters	24" deep, even multiples of 3" wide
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Hallway	3 feet wide
All rooms must have at least one window	

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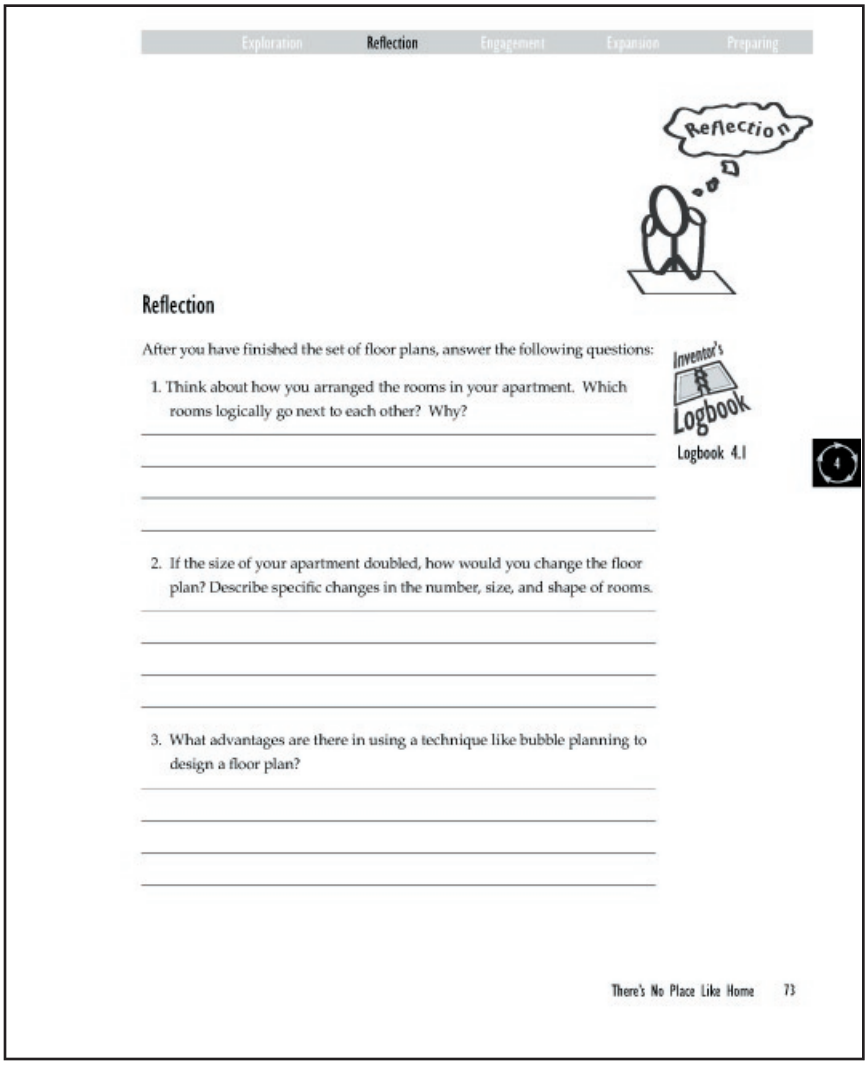

Exploration Reflection Engagement Expansion Preparing

Reflection

Reflection

After you have finished the set of floor plans, answer the following questions:

1. Think about how you arranged the rooms in your apartment. Which rooms logically go next to each other? Why?

2. If the size of your apartment doubled, how would you change the floor plan? Describe specific changes in the number, size, and shape of rooms.

3. What advantages are there in using a technique like bubble planning to design a floor plan?

Inventor's Logbook

Logbook 4.1

4

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Reflection

After completing the *Exploration* activity, students will need to reflect on the knowledge and experience they have acquired to answer the following questions.

1. Think about how you arranged the rooms in your apartment. Which rooms logically go next to each other? Why? *Houses are usually arranged into a "public area" containing rooms such as the living room, dining room, kitchen, and half bath and a "private area" containing rooms such as bedrooms and family bathrooms. This separation allows guests to be entertained easily while still providing a personal space for the residents of the house. Apartments may not have a complete separation between these two areas, but the same principle applies, and bedrooms are usually placed in more isolated locations.*

2. If the size of your apartment doubled, how would you change the floor plan? Describe specific changes in room sizes, shapes, and number of rooms. *Answers will vary. Simply doubling all the room sizes will not produce a good design, since walls will simply get farther apart. It may be best to use the space to expand several tight spaces, and then add additional elements that could not be fit into the original plan. Extra bedrooms, an extra bath, or an office/study are common choices.*

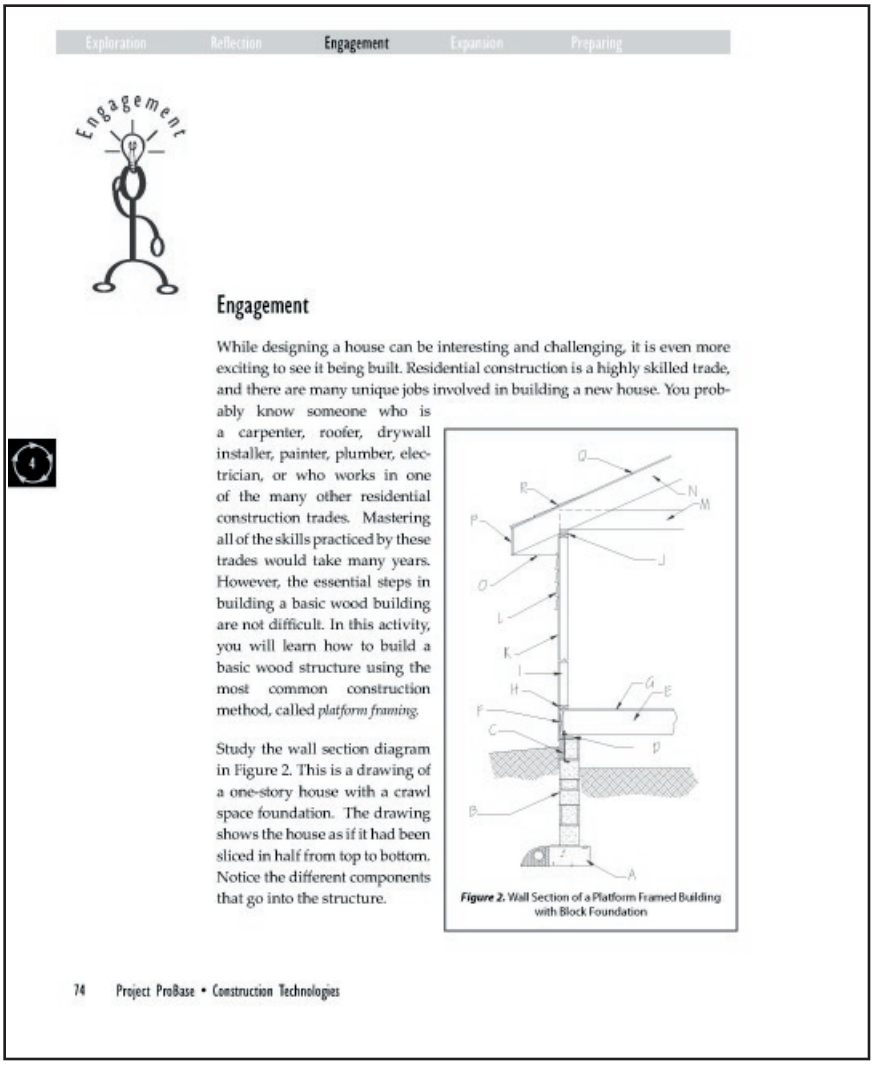
3. What advantages are there in using a technique like bubble planning to design a floor plan? *Bubble plans let designers think about the general spaces in a plan without having to decide on the exact locations of walls, doors, and windows. This method of drawing often produces floor plans that better reflect the true needs and desires of the people living in the home.*

Engagement

This activity revolves around the construction of a full-size, 4-foot-wide wall section (a scale model is an option). This is probably the most intense activity in the entire nine-week unit, and will require some planning and facility/materials preparation. Refer to the previous sections for information on facility use, equipment, and materials. These items should be in place on the first day of the *Engagement* activity. To save materials, the wall section can be made narrower than four feet. However, a narrower section may not be stable enough to stand without bracing. Also, a four-foot section is recommended since it is the smallest width that allows a whole number of studs, joists, and sheathing materials at standard spacing.

Students will spend the first part of this activity researching the names, sizes, and construction techniques for their section of the structure. Students will present this information to the rest of the class before beginning the actual construction process. The construction phase will be more successful if students are required to have complete and detailed information on the part of the structure before proceeding. This will minimize the amount of direct instruction for the instructor.

The Internet will be a useful resource for students, as will almost any text on residential construction.



Exploration Reflection Engagement Expansion Preparing

Engagement

Engagement

While designing a house can be interesting and challenging, it is even more exciting to see it being built. Residential construction is a highly skilled trade, and there are many unique jobs involved in building a new house. You probably know someone who is a carpenter, roofer, drywall installer, painter, plumber, electrician, or who works in one of the many other residential construction trades. Mastering all of the skills practiced by these trades would take many years. However, the essential steps in building a basic wood building are not difficult. In this activity, you will learn how to build a basic wood structure using the most common construction method, called *platform framing*.

Study the wall section diagram in Figure 2. This is a drawing of a one-story house with a crawl space foundation. The drawing shows the house as if it had been sliced in half from top to bottom. Notice the different components that go into the structure.

Figure 2. Wall Section of a Platform Framed Building with Block Foundation

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One very thorough source (available both on the internet and in print) is the Details for Conventional Wood Frame Construction manual, available from the American Wood Council (http://www.awc.org). This can be downloaded for free.

The construction phase will be labor-intensive for both students and instructors. It is important that students receive suitable instruction about safe and proper use of hand tools and power tools. This instruction must be included in the unit before construction begins. Wherever possible, hand tools have been suggested instead of power tools. The use of hand tools involves more students in the construction process and provides a greater margin of safety. It also encourages students to "measure twice and cut once," since each cut requires more of their own effort.

As a class, you will be building a life-sized or scaled section of a house that looks like Figure 2 on the previous page. Your instructor will divide your class into six groups. Each group will be responsible for one part of the structure.

Group 1: Foundation (Items A-C)
Group 2: Floor Platform (Items D-G)
Group 3: Walls and Exterior Sheathing (Items H-L)
Group 4: Ceiling Joists and Rafters (Items M-N)
Group 5: Roofing and Cornice Detail (Items O-R)
Group 6: Plumbing and Electrical (Not shown on section view)

As a group, research your part of the structure to find out how it is built. Consider each item and answer the following questions:

- What is the name of this item?
- What material is it made of?
- What is the cost of the material?
- What size is it? (Include length, width, and thickness, if applicable.)
- How is it attached to the rest of the structure?
- How is construction scheduled?

Your instructor will show you resources that will help you answer these questions. After you find the answers, you will present the information you find to the rest of the class. Once all groups have presented, you will collect your materials and tools and start building! Your instructor will have instructions about how to work efficiently on building the structure.

To complete the structure in the time allotted, groups will need to work at the same time, even if there is no structure in place to install their materials. Some parts, like the floor platform, walls, and rafters, will need to be measured and built on the classroom floor, then lifted into place once the structure is ready. The foundation group should be given as much help as needed in the beginning of the project, since other groups depend on them the most. The footer can be simulated with concrete blocks laid at right angles to the wall, or a true footer can be poured. To save time and materials, only two to three courses of block should be laid.

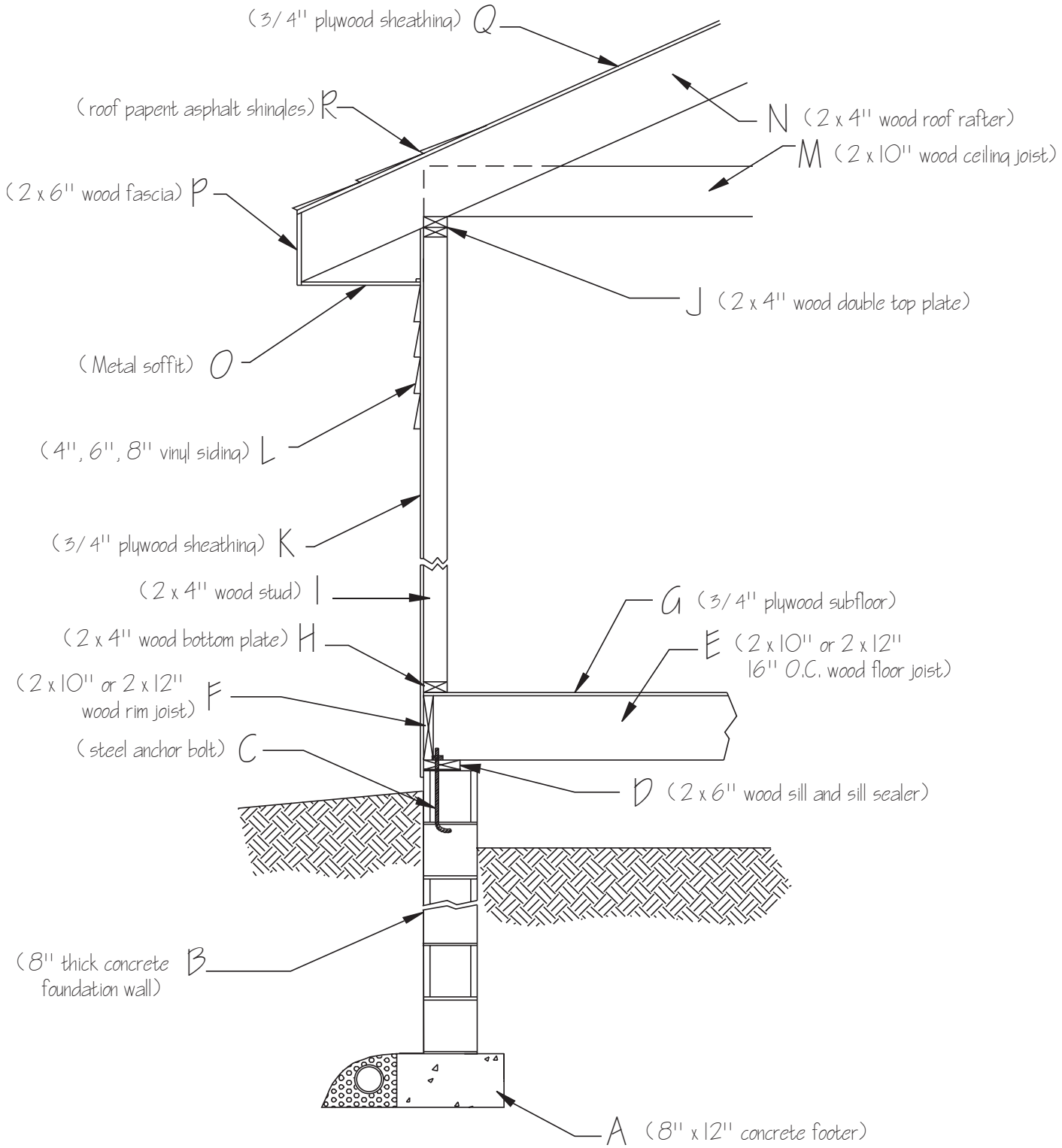
The rafters may be cut at any suitable pitch. To reduce the height of the structure and provide greater safety, a low pitch such as 3/12 is suggested. The inside end of the joists and rafters will need to be braced with other lumber. If two classes are each building a wall section, the two halves can be combined into one structure. (See illustrations on following pages.)

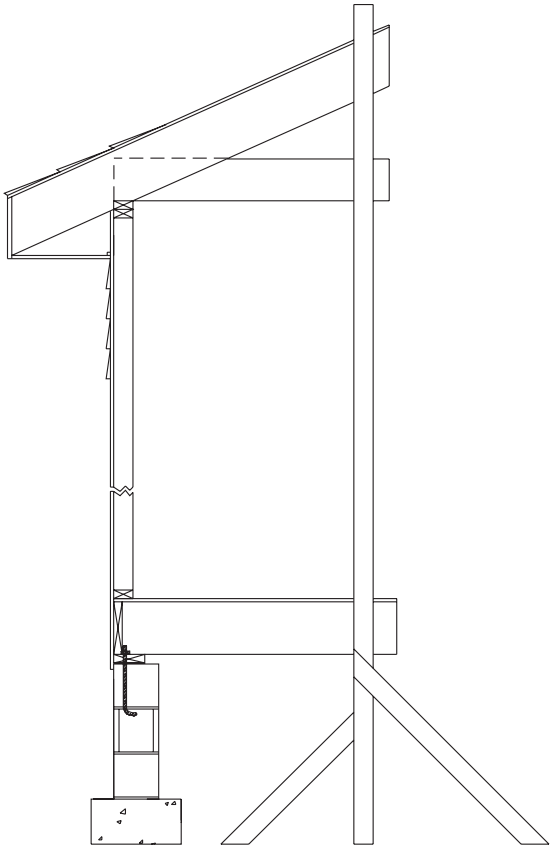
The plumbing and electrical group will install one outlet and two rough fittings (with water stop valve) for a sink. To avoid the risk of fire in soldering, most of this work can be done off of the structure, and then added as the wall nears completion.

Most materials in this activity can be reused for future projects. The foundation block and roof deck will be the hardest items to break down. OSB sheathing is harder to remove in one piece than plywood, although its cost is much lower.

Teaching Tips

You may find it easier to have the same teams that researched a part of the wall section actually build that part of the wall section. In addition, you may want to develop a schedule for installation and impose deadlines on each team. The teams should develop a detailed plan before they begin installation to help them meet their deadline.

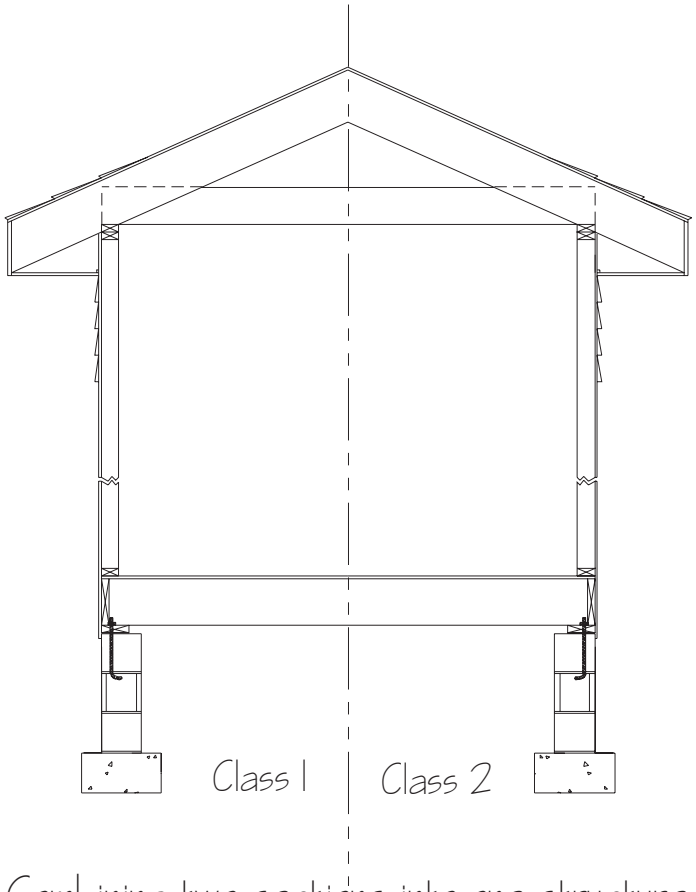

(3/4" plywood sheathing) Q
(roof papent asphalt shingles) R
N (2 x 4" wood roof rafter)
M (2 x 10" wood ceiling joist)
(2 x 6" wood fascia) P
J (2 x 4" wood double top plate)
(Metal soffit) O
(4", 6", 8" vinyl siding) L
(3/4" plywood sheathing) K
(2 x 4" wood stud) I
G (3/4" plywood subfloor)
(2 x 4" wood bottom plate) H
E (2 x 10" or 2 x 12" 16" O.C. wood floor joist)
(2 x 10" or 2 x 12" wood rim joist) F
(steel anchor bolt) C
D (2 x 6" wood sill and sill sealer)
(8" thick concrete foundation wall) B
A (8" x 12" concrete footer)



Possible bracing for one wall section

Notes:

Notes:

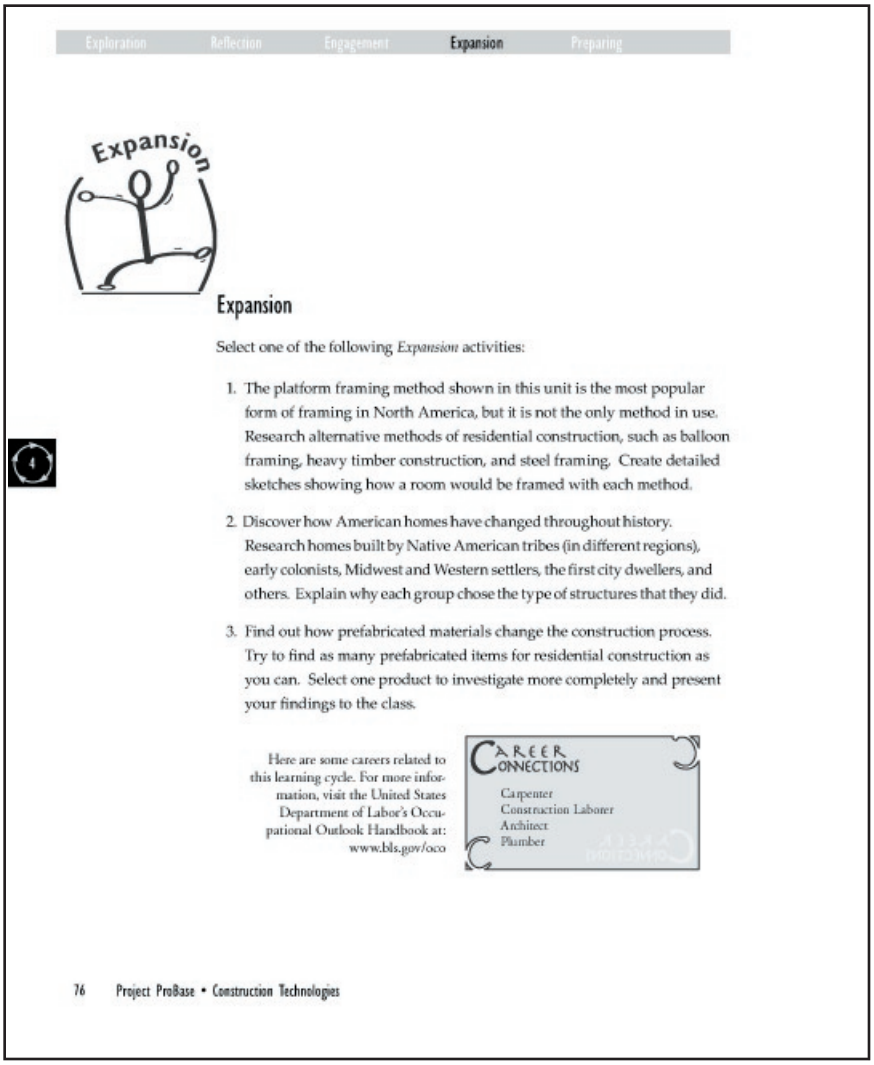


Combining two sections into one structure

Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explored in this learning cycle.

1. The platform framing method shown in this unit is the most popular form of framing in North America, but it is not the only method in use. Research alternative methods of residential construction, such as balloon framing, heavy timber construction, and steel framing. Create detailed sketches showing how a room would be framed with each method.



Exploration Reflection Engagement Expansion Preparing

Expansion

Expansion

Select one of the following *Expansion* activities:

1. The platform framing method shown in this unit is the most popular form of framing in North America, but it is not the only method in use. Research alternative methods of residential construction, such as balloon framing, heavy timber construction, and steel framing. Create detailed sketches showing how a room would be framed with each method.
2. Discover how American homes have changed throughout history. Research homes built by Native American tribes (in different regions), early colonists, Midwest and Western settlers, the first city dwellers, and others. Explain why each group chose the type of structures that they did.
3. Find out how prefabricated materials change the construction process. Try to find as many prefabricated items for residential construction as you can. Select one product to investigate more completely and present your findings to the class.

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

Career Connections
Carpenter
Construction Laborer
Architect
Plumber

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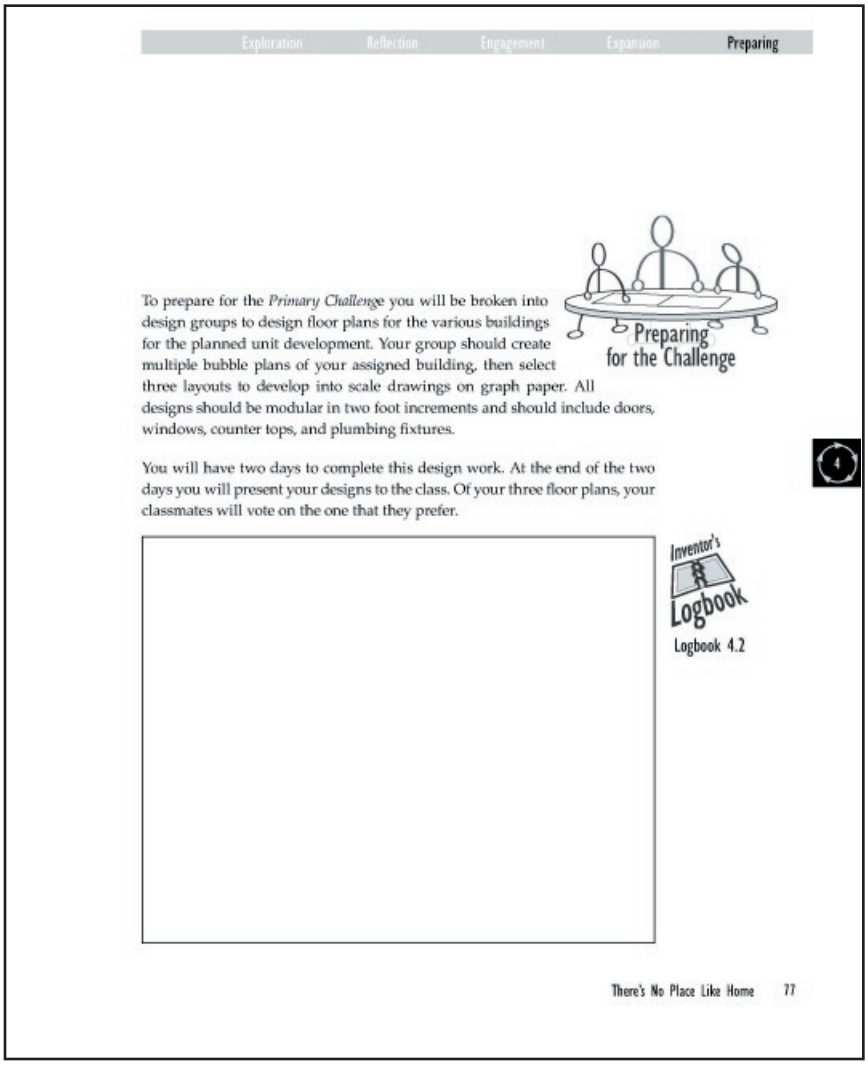
2. Discover how American homes have changed throughout history. Research homes built by Native American tribes (in different regions), early colonists, Midwest and Western settlers, the first city dwellers, and others. Explain why each group chose the type of structures that they did.

3. Find out how prefabricated materials change the construction process. Try to find as many prefabricated items for residential construction as you can. Select one product to investigate more completely and present your findings to the class.



Exploration Reflection Engagement Expansion **Preparing**

Preparing for the Challenge

To prepare for the *Primary Challenge* you will be broken into design groups to design floor plans for the various buildings for the planned unit development. Your group should create multiple bubble plans of your assigned building, then select three layouts to develop into scale drawings on graph paper. All designs should be modular in two foot increments and should include doors, windows, counter tops, and plumbing fixtures.

You will have two days to complete this design work. At the end of the two days you will present your designs to the class. Of your three floor plans, your classmates will vote on the one that they prefer.

Inventor's Logbook

Logbook 4.2

There's No Place Like Home 77

Preparing for the Challenge

Students will need to work with their *Primary Challenge* teams to develop floor plans for one of the buildings in the planned unit development. Each group should be assigned one of the buildings from the list in the Student Guide. If there are more than six groups, extra groups can work on a different floor plan for the single-family homes or the duplexes. If there are fewer groups, the two-story house or the duplex can be omitted.

Floor plans should be to scale. An architectural scale of ¼" = 1' is the most common size for floor plans, although this scale will require students to use large sheets of paper. Students will also need some guidance as to what details to include in their floor plans. Depending on time and skill level, doors, windows, fixtures, appliances, and rooms dimensions may be included or omitted for the class.

Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your needs.

Each group will design one of the buildings from the following list:

Community Center – 5,000 square feet

The community center should have a versatile floor plan so that it can be used for a variety of events, such as conferences, club meetings, community meals, recreation, small concerts, etc. The building must be fully accessible for people with disabilities.

Retail Center – 5,000 square feet (total)

The retail center should have separate spaces with separate entrances for multiple businesses. Decide what types of businesses you would like to attract and design the areas to fit those uses. Some options might include a convenience store, bike shop, bank, or deli. The structure should also have utility areas for employees, such as break rooms, restrooms, stock rooms, etc. Like the community center, the building must be fully accessible for people with disabilities.

Single-Family Residence, One Story – 1,200-1,800 square feet

This single-family residence should have three bedrooms and at least 1½ baths, in addition to other living areas. It may include an attached or detached one-car garage. A basement is not required.

Single-Family Residence, Two Stories – 1,600-2,400 square feet

This single-family residence should have three bedrooms and at least 1½ baths in addition to other living areas. It may include an attached or detached two-car garage. A basement is not required.

Two-Family Residence (Duplex) – 2,000-3,000 square feet (total)

Each side of the duplex should have two bedrooms and at least one bathroom in addition to other living areas. It should include two one-car garages. The two sides may be symmetrical, but non-symmetrical designs are also possible.

Apartment/Condominium Complex – 600-1,000 square feet per unit

The apartment complex should have between four and tweleve units. Units should be a mix of studio, one-bedroom, and two-bedroom units. The complex can have one main entrance for all units, or each unit can have its own outside entrance.

There's No Place Like Home

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Bubble Plans	Created a large number of concept sketches that show evidence of thoughtful design.	Created a large number of concept sketches. The concepts are fairly similar and lack breadth.	Created a smaller number of concept sketches that show evidence of thoughtful design.	Created a minimal number of concept sketches with little thought to design details.	
Floor Plans	Completed a detailed, practical floor plan incorporating the constraints discussed in the *Exploration* section.	Completed a practical floor plan, but not all details or dimensions were standard.	The floor plan was incomplete, lacking much detail, and/or impractical.	The floor plan was incomplete and showed little attention to concepts taught in class.	
Wall Section Research	Accurately answered assigned questions, successfully prepared a presentation, and was well-prepared for construction.	Accurately answered assigned questions, successfully prepared a presentation, but lacking detail needed for construction.	Answered assigned questions and prepared a presentation, but had some inaccuracies.	Presented a minimal amount of information related to the assigned questions.	
Construction	Worked as part of a group to complete assigned section accurately and on time.	Worked as part of a group to complete assigned section accurately and on time. Did not share equal portion of responsibility.	Worked as part of a group to complete assigned section. Workmanship needs improvement.	Made minimal contribution to completion of the assigned section.	
Preparing for the Challenge	Completed a detailed, practical floor plan incorporating the constraints discussed in the *Exploration* section.	Completed a practical floor plan, but not all details or dimensions were standard.	The floor plan was incomplete, lacking much detail, and/or impractical.	The floor plan was incomplete and showed little attention to concepts taught in class.	
				Total	

Learning Cycle Five

Seeing Green

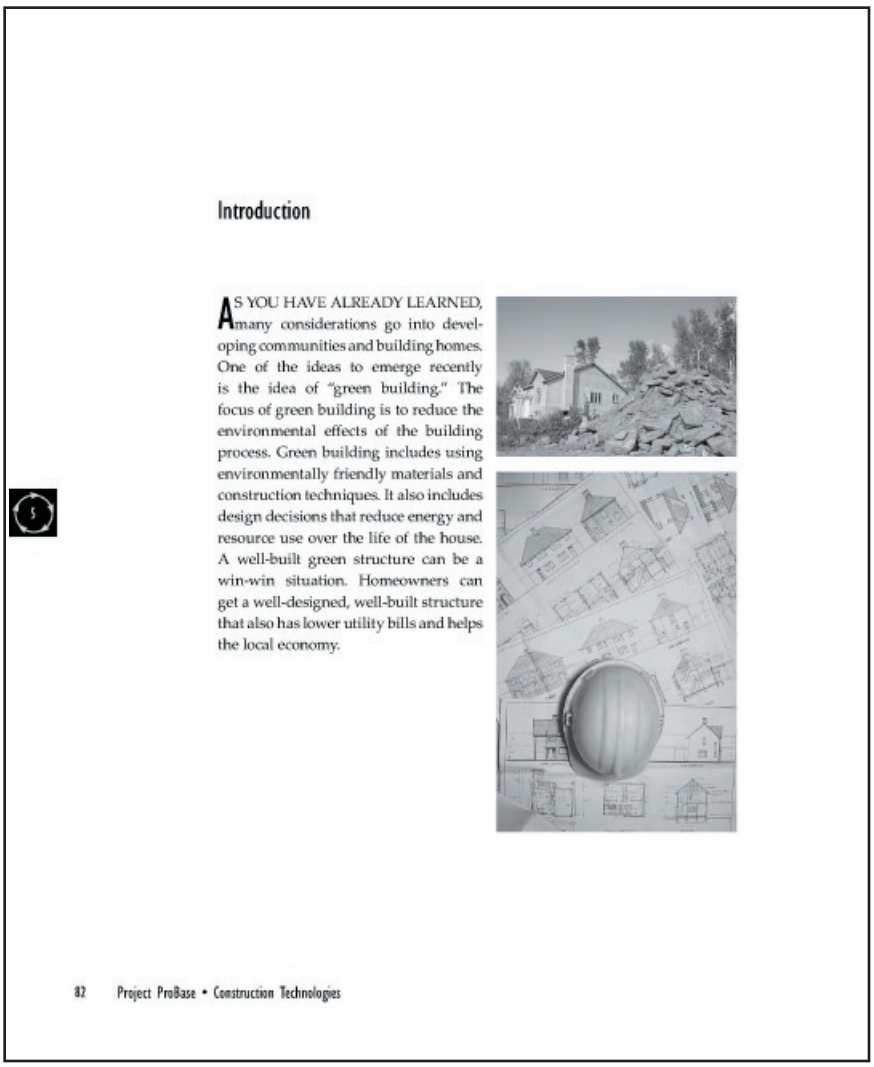
5

Seeing Green

Introduction

In this learning cycle, students will learn how current green building trends are changing the way residential buildings are being designed and built. They will also experience those differences hands-on as they model some of the green building construction techniques.

The *Exploration* section covers the concepts and structure of the most prominent green building standard, LEED-NC, published by the U.S. Green Building Council. (LEED-NC stands for Leadership in Energy and Environmental Design – New Construction.) Students will research specific sections of LEED-NC and apply them to their designs. The *Engagement* section covers framing techniques suitable for green building credit. These framing techniques, often called "optimum value engineering," are designed to minimize material costs while still meeting structural requirements. Students will build models or full-size sections showing these advanced framing details. Finally, students will work toward the *Primary Challenge* by selecting green building techniques for the planned unit development.



Introduction

AS YOU HAVE ALREADY LEARNED, many considerations go into developing communities and building homes. One of the ideas to emerge recently is the idea of "green building." The focus of green building is to reduce the environmental effects of the building process. Green building includes using environmentally friendly materials and construction techniques. It also includes design decisions that reduce energy and resource use over the life of the house. A well-built green structure can be a win-win situation. Homeowners can get a well-designed, well-built structure that also has lower utility bills and helps the local economy.

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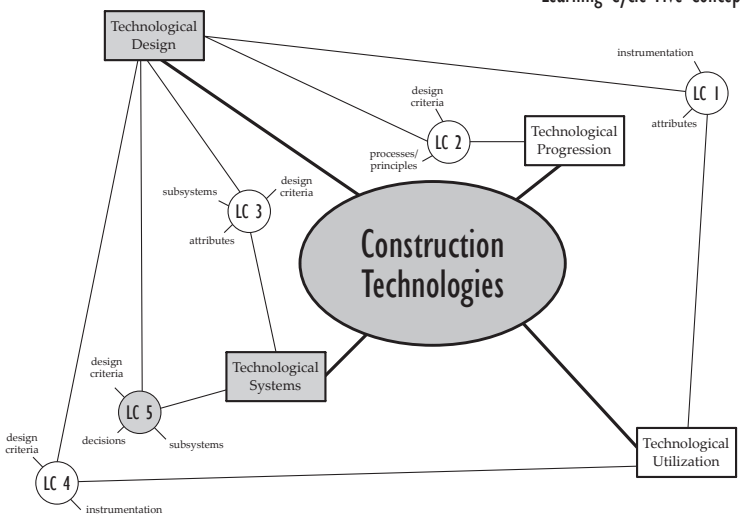
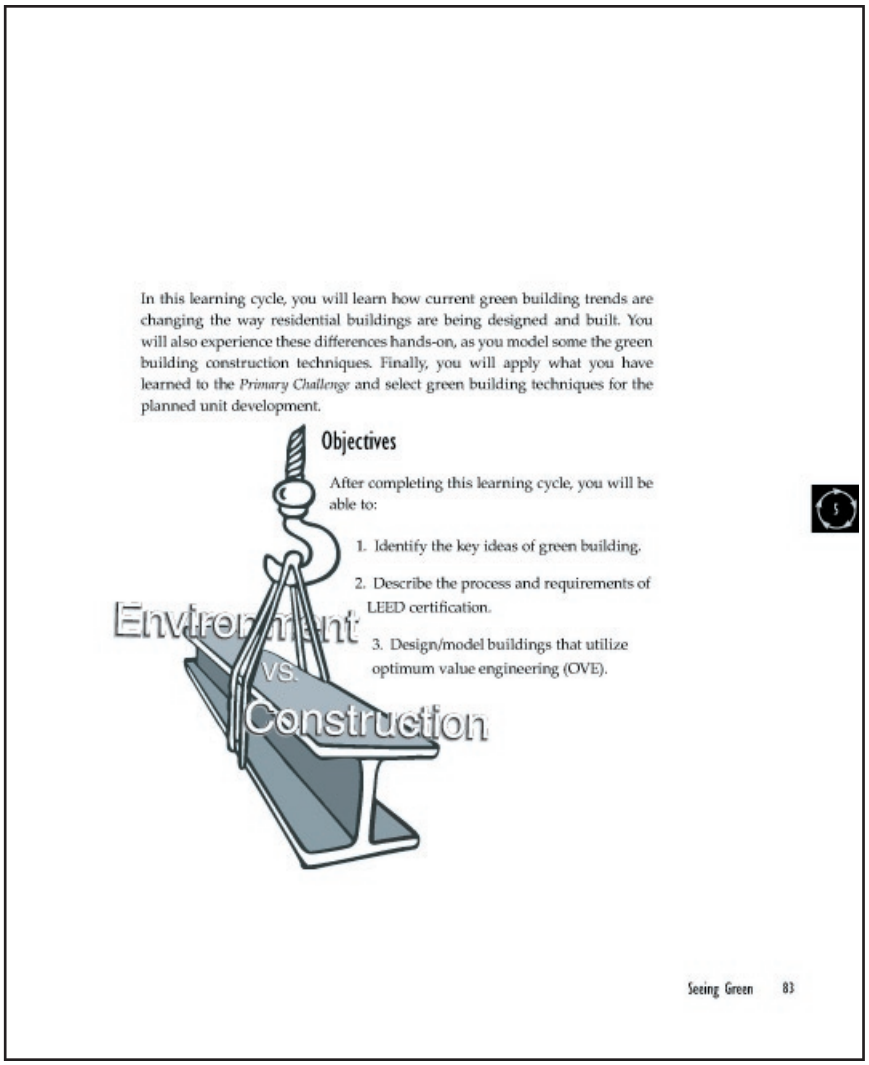
ConstructionTechnologies
Learning Cycle Five Concept Map





In this learning cycle, you will learn how current green building trends are changing the way residential buildings are being designed and built. You will also experience these differences hands-on, as you model some the green building construction techniques. Finally, you will apply what you have learned to the *Primary Challenge* and select green building techniques for the planned unit development.

Objectives

After completing this learning cycle, you will be able to:

1. Identify the key ideas of green building.
2. Describe the process and requirements of LEED certification.
3. Design/model buildings that utilize optimum value engineering (OVE).

Environment vs. Construction

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Objectives and Essential Questions

After completing this learning cycle, students will be able to:

1. Identify the key ideas of green building.

Essential Question 4a: What are the systems and subsystems involved in the various contexts of technology?

2. Describe the process and requirements of LEED certification.

Essential Question 7c: What design criteria are typically considered when developing new technologies and how do these influence the final product/system design?

3. Design/model buildings that utilize Optimum Value Engineering.

Essential Question 7d: How are decisions made regarding information that should be discarded or ignored?

Facility Requirements

The *Exploration* and *Engagement* sections will require a computer lab with Internet access. Students will be researching various items related to green building. The *Engagement* activity also includes the construction of framing sections. While not as large as the full-scale wall section in the previous learning cycle, these will still be fairly large. Some will be eight feet high and require a room with a high ceiling and ample floor space.

If space is an issue, these framing sections can be completed as scale models instead, in which case the facility requirements will be much smaller. There are no special requirements for the *Preparing for the Challenge* activities.

Equipment

The following items are suggested. Other tools may be used if appropriate. The quantities listed below are approximate.

(8) Hammers
(8) Tape measures
(4) Quick squares
Rafter square
(4) Crosscut saws
Circular saw
Electric drill with ½" bit & 1" bit

Materials

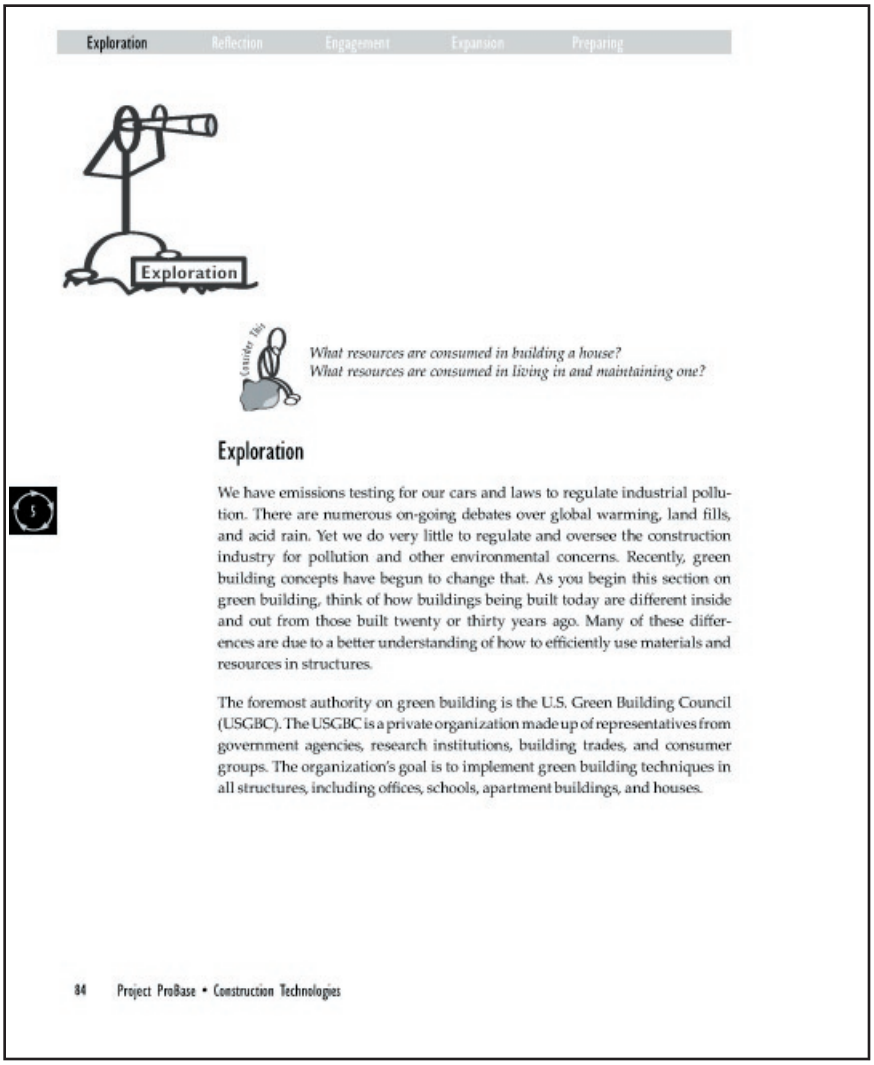
The quantities listed below are approximate. Materials from the previous learning cycle may be reused.

Item	Size	Qty
2x4	8 feet	20
2x4, pressure-treated	8 feet	2
2x10	8 feet	2
2x12	8 feet	1
½" OSB or plywood	4x8	1
¾" OSB or plywood	4x8	1
10d nails	~	5 lb
16d nails	~	5 lb

Also, large-size paper (11x17 or larger) will be required for the *Preparing for the Challenge* activity.

Suggested Daily Outline

Estimated number of 50-minute class periods: **5**



Exploration Reflection Engagement Expansion Preparing

Exploration

Consider This

What resources are consumed in building a house?
What resources are consumed in living in and maintaining one?

Exploration

We have emissions testing for our cars and laws to regulate industrial pollution. There are numerous on-going debates over global warming, land fills, and acid rain. Yet we do very little to regulate and oversee the construction industry for pollution and other environmental concerns. Recently, green building concepts have begun to change that. As you begin this section on green building, think of how buildings being built today are different inside and out from those built twenty or thirty years ago. Many of these differences are due to a better understanding of how to efficiently use materials and resources in structures.

The foremost authority on green building is the U.S. Green Building Council (USGBC). The USGBC is a private organization made up of representatives from government agencies, research institutions, building trades, and consumer groups. The organization's goal is to implement green building techniques in all structures, including offices, schools, apartment buildings, and houses.

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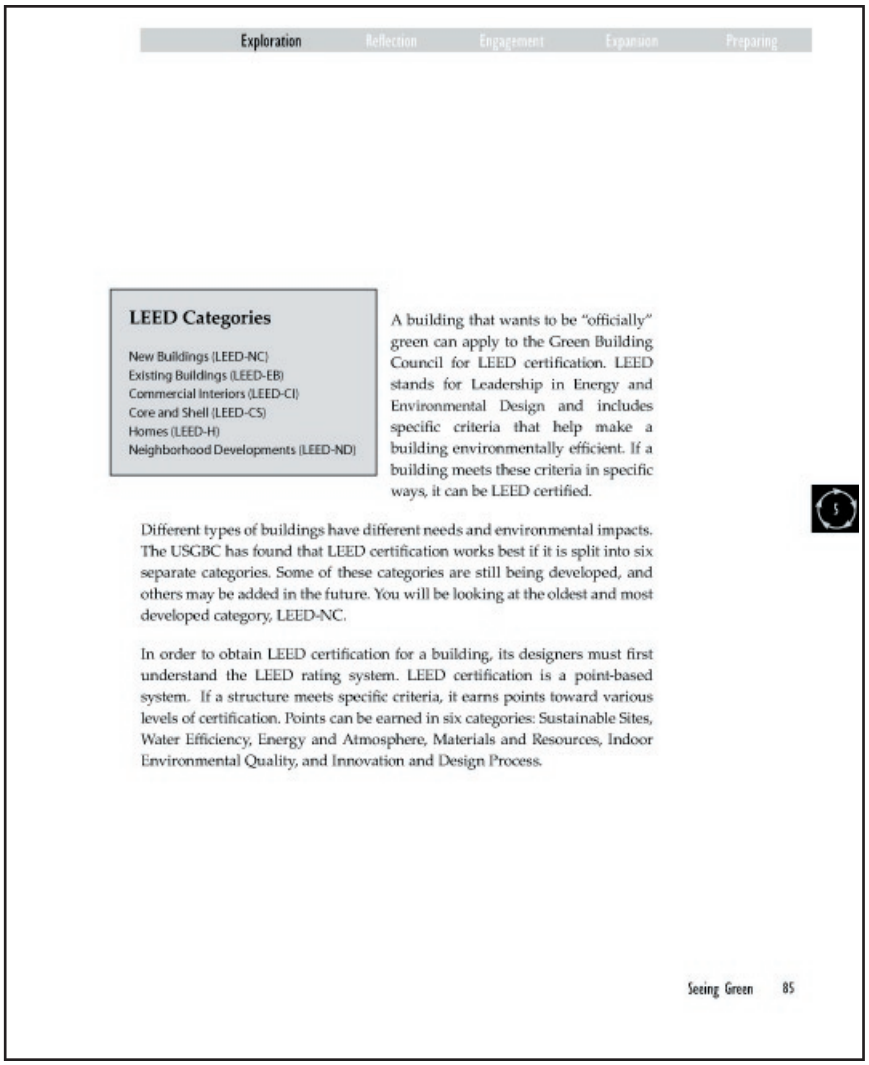
Day One	Day Two	Day Three
Introduction, *Exploration*	*Exploration*	*Reflection, Engagement*
Day Four	**Day Five**	
Engagement	*Engagement*	



Exploration Reflection Engagement Expansion Preparing

LEED Categories

New Buildings (LEED-NC)
Existing Buildings (LEED-EB)
Commercial Interiors (LEED-CI)
Core and Shell (LEED-CS)
Homes (LEED-H)
Neighborhood Developments (LEED-ND)

A building that wants to be "officially" green can apply to the Green Building Council for LEED certification. LEED stands for Leadership in Energy and Environmental Design and includes specific criteria that help make a building environmentally efficient. If a building meets these criteria in specific ways, it can be LEED certified.

Different types of buildings have different needs and environmental impacts. The USGBC has found that LEED certification works best if it is split into six separate categories. Some of these categories are still being developed, and others may be added in the future. You will be looking at the oldest and most developed category, LEED-NC.

In order to obtain LEED certification for a building, its designers must first understand the LEED rating system. LEED certification is a point-based system. If a structure meets specific criteria, it earns points toward various levels of certification. Points can be earned in six categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation and Design Process.

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Exploration

This section introduces students to LEED-NC, the most common set of green building criteria currently in use. LEED-NC is published by the U.S. Green Building Council (http://www.usgbc.org/), an organization that also reviews the applications for certification to LEED. (The full name, Leadership in Energy and Environmental Design – New Construction, is rarely used.) LEED is structured as a points-rating system, where a building earns point credits for specific actions that reduce energy and environmental impact.

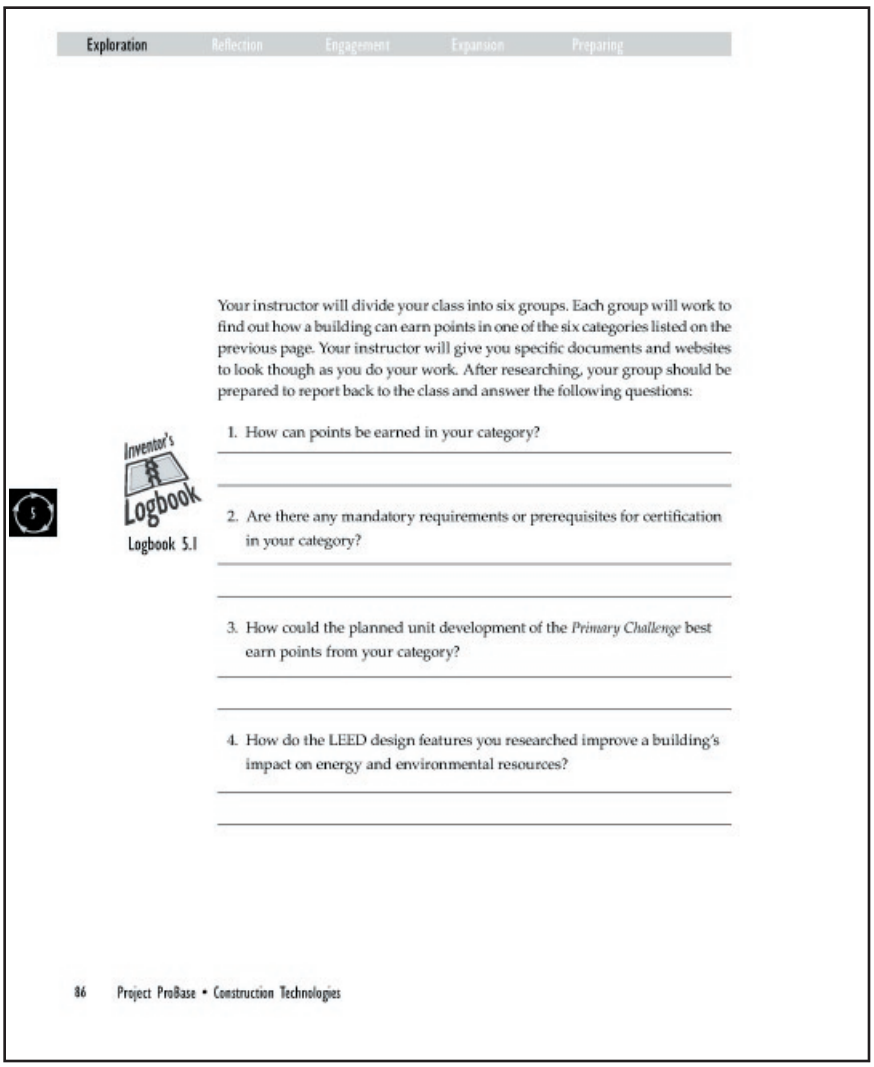
A building that earns a sufficient number of credits can achieve LEED certification. LEED certification also has certain basic requirements, called prerequisites, which are mandatory for achieving certification.

The entire LEED-NC rating system is large and fairly complex. While not difficult to understand, there are many credits and numerous details to consider. The major activity in this section asks student groups to research just a part of the rating system and summarize its most important features for the rest of the class. Listed below is a brief description of the six LEED certification categories.

- The *Sustainable Sites* category includes the measures taken to prevent the harmful impact of construction on undeveloped lands and the effort taken to improve previously contaminated sites.
- The *Water Efficiency* category examines the measures taken to reduce the excessive usage of water.
- The *Energy and Atmosphere* category includes the environmentally and economically beneficial practices that reduce energy consumption.

- The *Materials and Resources* category accounts for the efforts taken to re-use materials and use renewable materials.
- The *Indoor Environmental Quality* category measures strategies taken to increase the quality of the indoor environment, such as ventilation effectiveness and the control of contaminates.
- The *Innovation and Design Process* is aimed at recognizing projects that utilized both sustainable building concepts and innovative building techniques.

Student groups should research their assigned section of the LEED-NC system on the Internet. While many sites discuss LEED criteria, the most complete and accurate information will be found on the U.S. Green Building Council website. As of this writing, the most complete set of information was found in a document titled LEED Rating System Version 2.0, which is available as a free download. If Internet access is not available for all computers, it is possible to save this file and similar materials for offline access for students.



Exploration Reflection Engagement Expansion Preparing

Your instructor will divide your class into six groups. Each group will work to find out how a building can earn points in one of the six categories listed on the previous page. Your instructor will give you specific documents and websites to look though as you do your work. After researching, your group should be prepared to report back to the class and answer the following questions:

Inventor's Logbook

Logbook 5.1

1. How can points be earned in your category?

2. Are there any mandatory requirements or prerequisites for certification in your category?

3. How could the planned unit development of the *Primary Challenge* best earn points from your category?

4. How do the LEED design features you researched improve a building's impact on energy and environmental resources?

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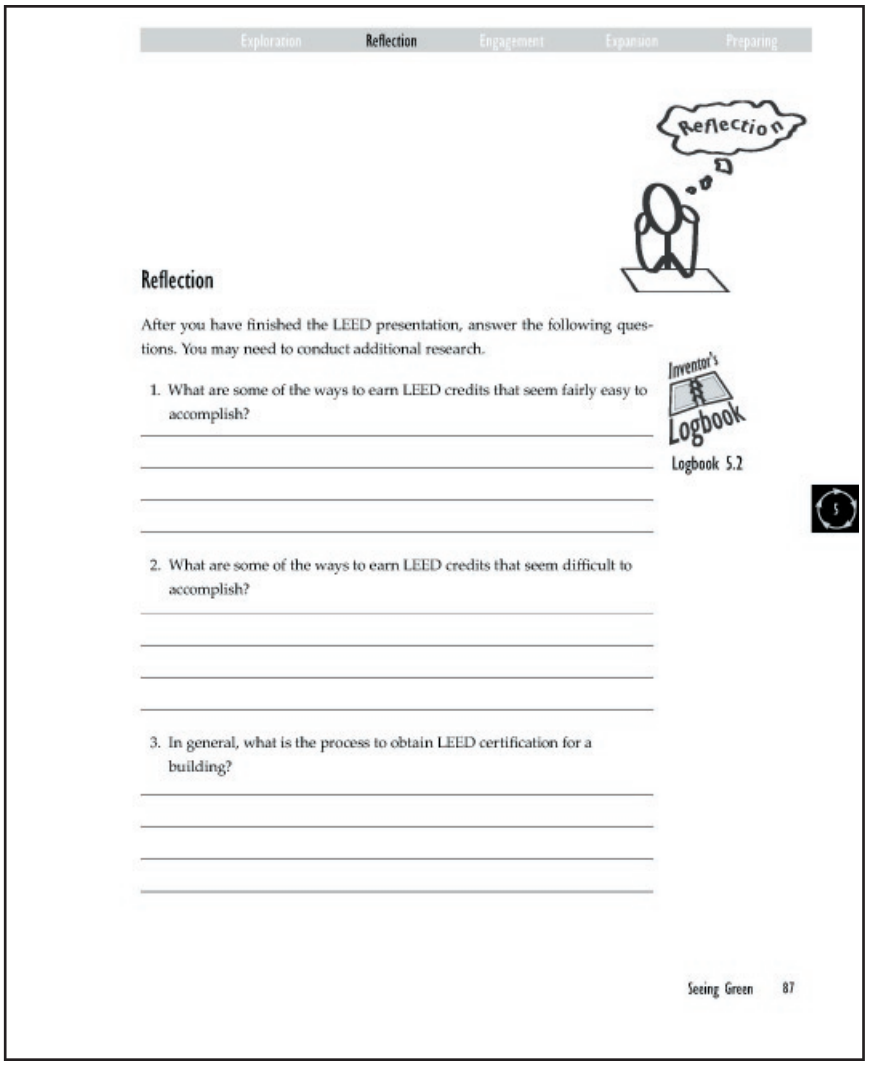
Student groups should share their findings with the class in a concise but accurate presentation. Encourage students to focus on the prerequisites and credits available in their assigned section of the rating system, and to provide an explanation of how those credits can be earned. Merely presenting this information in an accurate form should take each group six to eight minutes. The short LEED-NC Project Checklist is a list of all prerequisites and credits and might be very helpful in grading student presentations.



Exploration Reflection Engagement Expansion Preparing

Reflection

After you have finished the LEED presentation, answer the following questions. You may need to conduct additional research.

1. What are some of the ways to earn LEED credits that seem fairly easy to accomplish?

2. What are some of the ways to earn LEED credits that seem difficult to accomplish?

3. In general, what is the process to obtain LEED certification for a building?

Inventor's Logbook

Logbook 5.2

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Reflection

After completing the *Exploration* activity, students will need to reflect on the knowledge and experience they have acquired to answer the following questions.

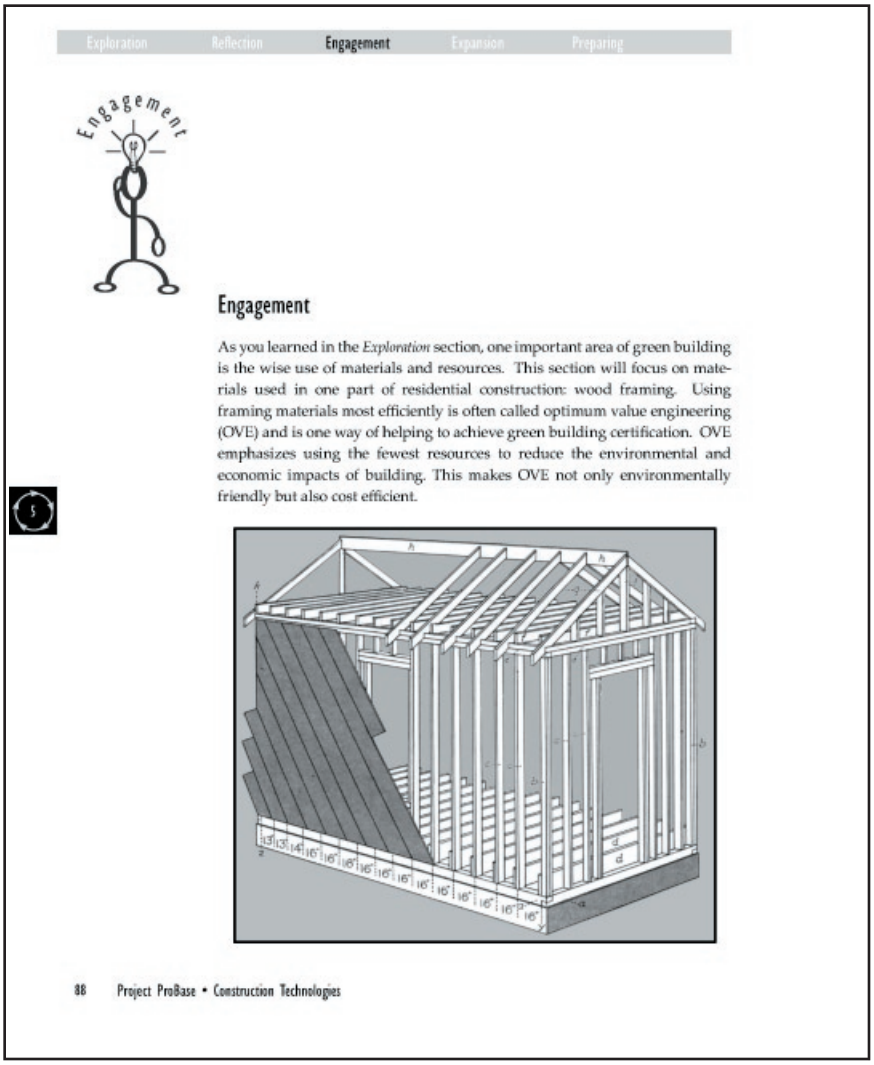
1. What are some of the ways to earn LEED credits that seem fairly easy to accomplish?
   Student answers will vary. Selection of materials, products, and landscaping may seem easy ways to earn credits.

2. What are some of the ways to earn LEED credits that seem difficult to accomplish?
   Student answers will vary. Credits that require major design modifications, such as site planning and sizing of a structure, will require more design work and seem harder to achieve.

3. In general, what is the process to obtain LEED certification for a building?
   The certification process is explained in detail on the USGBC web site. Certification begins with registering the building and paying a fee. This starts the process. The building's designers and builders must then prepare documentation for each credit that they want to earn. All this documentation is assembled into an application, which is reviewed by USGBC staff. If the required prerequisites and credits have been met, the building is awarded LEED certification.

Engagement

Students will need to research carefully to obtain useful information for the building phase of this activity. An Internet search for "optimum value engineering" or "advanced wall framing" as whole phrases will probably yield the best results. One excellent resource for students is the Advanced Wall Framing Technology Fact Sheet published by the Department of Energy's Office of Building Technology. It is available as a free download.



Exploration Reflection Engagement Expansion Preparing

Engagement

As you learned in the *Exploration* section, one important area of green building is the wise use of materials and resources. This section will focus on materials used in one part of residential construction: wood framing. Using framing materials most efficiently is often called optimum value engineering (OVE) and is one way of helping to achieve green building certification. OVE emphasizes using the fewest resources to reduce the environmental and economic impacts of building. This makes OVE not only environmentally friendly but also cost efficient.

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Student groups should select one of the framing techniques to build, or different techniques may be assigned to groups. The activity will be most useful if the framing sections are built as full-size models using standard tools. However, if materials or space are limited, the models may be made of different materials. For instance, ¾" plywood can be ripped into strips to make ½-scale lumber, or even smaller models can be made with balsa wood and glue.

Some areas that you might wish to consider are:

Stud, joist and truss spacing
Headers
Modular design
In-line framing
Window and door location and layout
Bracing
Top plates

With a partner, you will be researching optimum value engineering on the internet, and then building an example of one OVE technique. Search the internet using terms like "optimum value engineering" and "advanced wall framing." Read about how builders are reducing material and labor costs in framing, while still ensuring a rigid structure. Select one of the techniques that you found, and create a real-life model of it. Your instructor will give you instructions on what scale and materials to use in building your model.

Upon completion of your model, write a brief description that explains how your design used OVE principles. Be sure to also explain how these principles satisfy the LEED requirements for materials use and redirection.

This activity might be concluded with student presentations that discuss material use and green building requirements, as well as a display of their model(s). This activity also might be suitable for presentation to a larger audience, such as a hallway display or school assembly.

As students build their framing section, they should have a clear idea of how the technique that they are modeling minimizes material use. If extra material is available, student groups could build two models–one using conventional techniques, and one using advanced framing techniques–and compare material use. Students could also be challenged to calculate the savings in material if their chosen technique was used throughout an average-sized house.

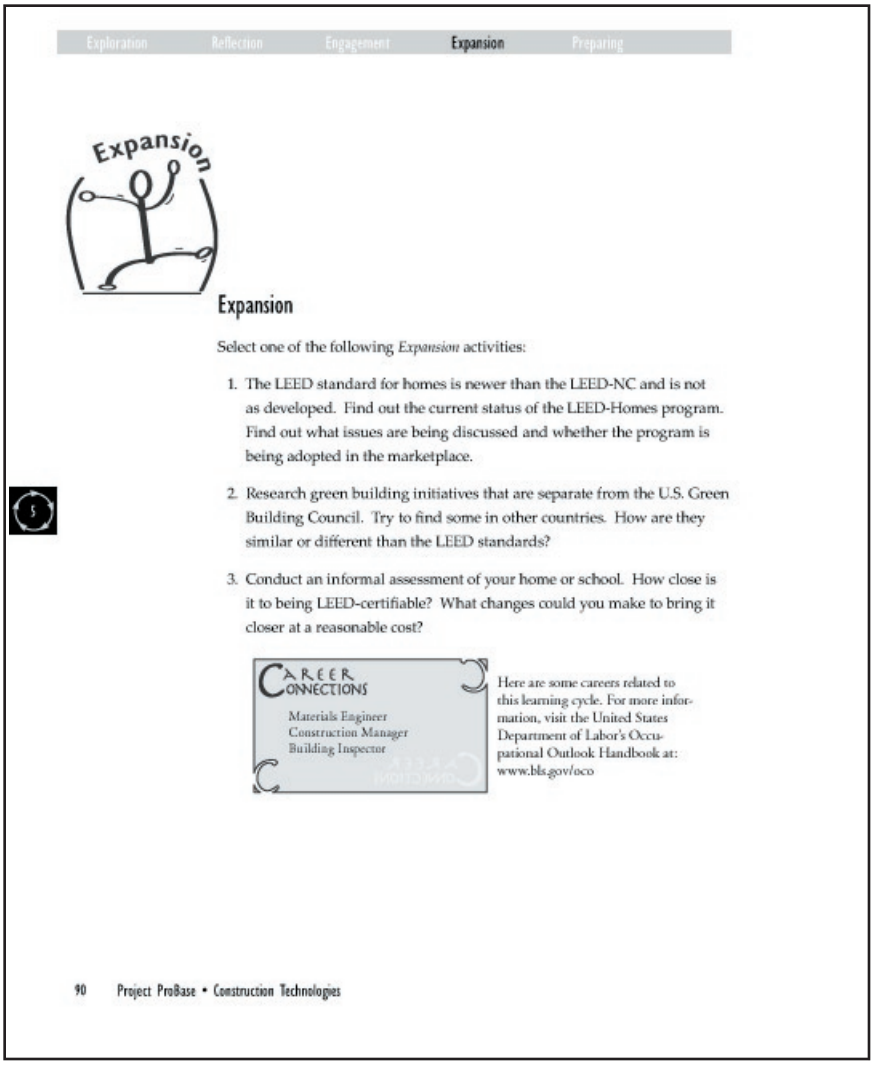
Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into the concepts explored in this learning cycle.

1. The LEED standard for homes is newer than the LEED-NC and is not as developed. Find out the current status of the LEED-Homes program. Find out what issues are being discussed and whether the program is being adopted in the marketplace.

2. Research green building initiatives that are separate from the U.S. Green Building Council. Try to find some in other countries. How are they similar or different than the LEED standards?

3. Conduct an informal assessment of your home or school. How close is it to being LEED-certifiable? What changes could you make to bring it closer at a reasonable cost?



Exploration Reflection Engagement Expansion Preparing

Expansion

Expansion

Select one of the following *Expansion* activities:

1. The LEED standard for homes is newer than the LEED-NC and is not as developed. Find out the current status of the LEED-Homes program. Find out what issues are being discussed and whether the program is being adopted in the marketplace.

2. Research green building initiatives that are separate from the U.S. Green Building Council. Try to find some in other countries. How are they similar or different than the LEED standards?

3. Conduct an informal assessment of your home or school. How close is it to being LEED-certifiable? What changes could you make to bring it closer at a reasonable cost?

CAREER CONNECTIONS

Materials Engineer
Construction Manager
Building Inspector

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

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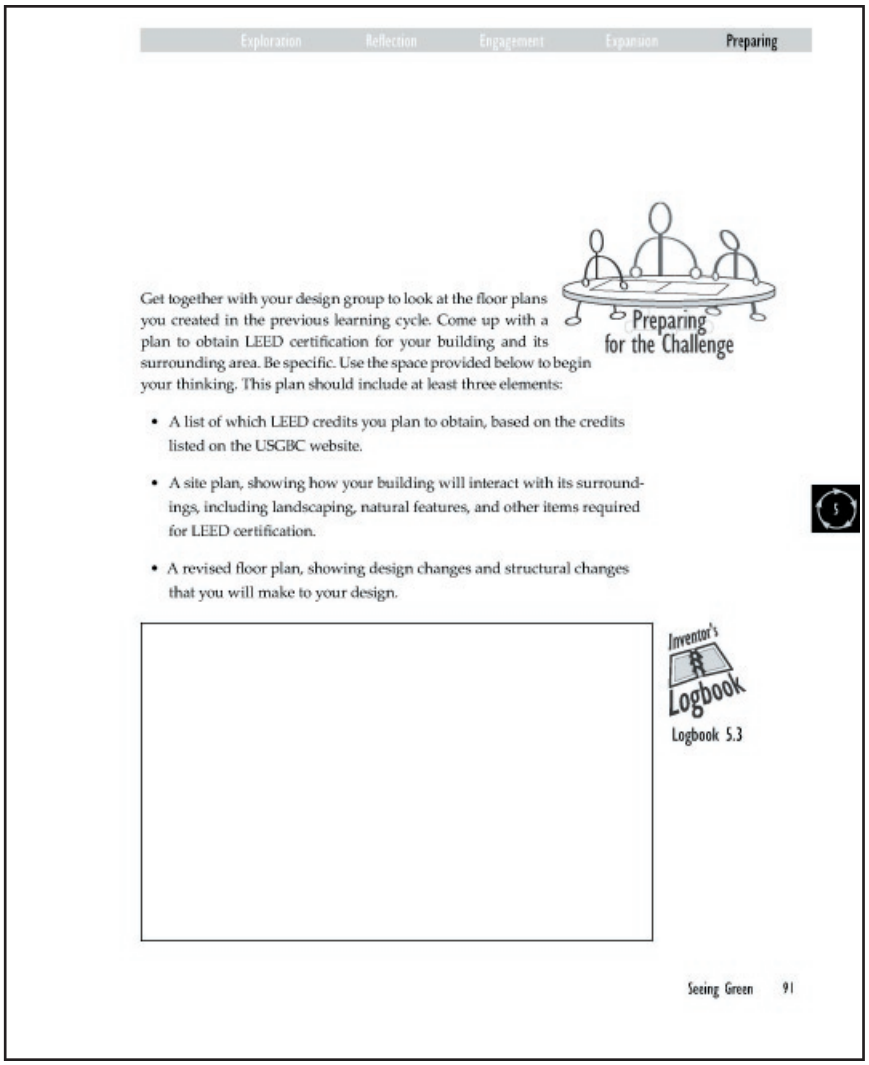


Exploration Reflection Engagement Expansion **Preparing**

Preparing for the Challenge

Get together with your design group to look at the floor plans you created in the previous learning cycle. Come up with a plan to obtain LEED certification for your building and its surrounding area. Be specific. Use the space provided below to begin your thinking. This plan should include at least three elements:

- A list of which LEED credits you plan to obtain, based on the credits listed on the USGBC website.
- A site plan, showing how your building will interact with its surroundings, including landscaping, natural features, and other items required for LEED certification.
- A revised floor plan, showing design changes and structural changes that you will make to your design.

Inventor's Logbook

Logbook 5.3

Seeing Green 91

Preparing for the Challenge

Students should regroup in their *Primary Challenge* teams. In this learning cycle, the goal is to revise the existing building plans to achieve LEED certification. Students are asked to develop a revised floor plan, a site plan, and a detailed checklist of LEED credits that the building will be able to achieve.

The key to this activity is for students to make very specific changes to their design. It may be tempting for some groups to list general goals such as "use advanced framing throughout the house" or "use green materials for the siding." These groups should be challenged to make their recommendations much more specific. If time permits, groups might even search for products and specify an exact product for certain materials.

Note that the LEED-NC rating system includes some items that are considered prerequisites that must be met by any structure seeking certification. The *Primary Challenge* teams must address all of these. The rest of the rating system uses credits for various actions. Teams are free to choose any combination of these credits to meet the minimum point requirements.

The results of this activity will become the final floor plans, site plans, and documents for the *Primary Challenge*. It might be helpful to remind students of the standards for high-quality scale drawings. These drawings may be at any scale that is convenient, although a scale of ¼"=1" or larger is recommended for floor plans to allow easy presentation.

Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your needs.

Seeing Green

Name: Date:

Element	Criteria				Points
	4	3	2	1	
LEED rating presentation	Presented accurate information on all prerequisites and credits, along with explanations of how to earn each.	Presented accurate information on all prerequisites and credits, but did not fully explain some of them.	Presented accurate information on prerequisites and credits, along with explanations, but did not cover each one.	Presented a minimal amount of information related to the assignment.	
Advanced framing research	Was well-prepared for construction and could explain how the assigned technique contributed to green building certification.	Was well-prepared for construction, but lacked detail on how the assigned technique contributed to green building certification.	Did not have enough information for independent completion of the project; needed help from other groups or instructor.	Presented a minimal amount of information related to the assignment.	
Construction	Worked as part of a group to complete assigned section accurately and on time.	Worked as part of a group to complete assigned section accurately and on time. Did not share equal portion of responsibility.	Worked as part of a group to complete assigned section. Workmanship needs improvement.	Made minimal contribution to completion of the assigned section.	
Preparing for the Challenge	Presented a detailed site plan, floor plan, and list of credits that are able to achieve certification.	Presented a site plan, floor plan, and list of credits that are able to achieve certification, but plans lacked some detail.	Plans were incomplete, lacking major detail, or did not earn enough credits for certification.	Plans were incomplete and showed little attention to concepts taught in class.	
				Total	

Appendix and Supplemental Materials

Appendix

Project ProBase
Enduring Understandings & Essential Questions

Students will understand:

1. that **technological progression** is driven by a number of factors, including individual creativity, product and systems innovation, and human wants and needs.
    a. How are new technologies **developed and marketed**?
    b. What social, cultural, and political **pressures** lead to the need or want for new technologies?
    c. What are the specific **roles of professionals** involved in technological adaptation and change?
    d. What **factors** need to be in place for new technologies to be viable in the national and international marketplace?
    e. What are the fundamental **processes/principles** used to develop new technologies?

2. that **technological** development for the solution of a problem in one context can **spinoff** for use in a variety of often unrelated applications.
    a. How do **technologies migrate** from one context (or location) to another and what are the implications?
    b. What **roles** do the patent, trademark, and copyright laws play in the **dissemination of** technological **ideas**?
    c. How have technological innovations caused **paradigm shifts** throughout history and what are these major shifts?

3. that **technological change** can be positive and/or negative, and can have intended and/or unforeseen social, cultural, environmental, and political consequences.
    a. What are some of the unforeseen **consequences** of specific technological changes throughout history?
    b. How can a technology cause both good and harm and how do humans prepare for or respond to these **impacts**?

4. how **technological systems** work, the components of those systems, and how they fit into the larger technological, economic, and social systems.
    a. What are the systems and **subsystems** involved in the various contexts of technology?
    b. What are the key elements of the various technological **systems** and what are the **relationships** between these systems?
    c. How do various technological **systems influence** the economy, society, the environment, and culture?

5. that there are compelling and controversial **issues** associated with the acquisition, development, use, and disposal of **resources**.
    a. What kinds of **resources** are required in each of the eight technological contexts?
    b. What is the **relative value** of specific resources used in technological systems?
    c. To what extent have **resource** issues (acquisition, development, use, and disposal) **affected** the direction of technological **development**?
    d. What **resources** are **needed** to solve a specific design problem (people, information, materials, tools, capital, energy, time, technical ability)?

Students will understand:

6. that the complexities of technological **design** involve **trade-offs** among competing **constraints** and requirements, including engineering, economic, political, social, and environmental considerations.
    a. To what extent have **optimal designs** been achieved in the eight technological context areas?
    b. What are the key **factors** that cause designers to make decisions about trade-offs, limitations, and constraints when designing new products and systems? (**Micro Factors**)
    c. How can members of the public, politicians, or the state of the economy **influence** the design of new technological products and systems? (**Macro Factors**)
    d. How can **social values** and **principles** guide in the development of solutions to technological problems?

7. that **technological design** is a systematic **process** used to initiate and refine ideas, solve problems, and maintain products and systems.
    a. What are the five primary **methods** through which technological **problems** are **solved** and how do they differ (i.e., troubleshooting, research and development, experimentation, invention and innovation, design problem solving)?
    b. To what extent can design problems be approached through a series of generic procedures (the **design loop**)?
    c. What **design criteria** are typically considered when developing new technologies (i.e., marketability, safety, useability, reliability, cost, materials, etc.) and how do these influence the final product/system design?
    d. How are **decisions** made regarding **information** that should be discarded or ignored?
    e. How can the **attributes** of design and the **principles** of design aid in the development of quality solutions?
    f. How can the establishment of relationships, controlling variables, categorizing techniques, and making inferences aid in the **development** of **new** technological **designs**?

8. how to **evaluate** the benefits, limitations, and **risks** associated with existing and proposed technologies.
    a. How does a **risk/benefit analysis** aid the designer in addressing potential harmful effects prior to development?
    b. What are some important **ethical decisions** that should be considered when developing any new technology?
    c. Are all product/system **designs** created for the purpose of adding **social value**?
    d. How are ethical **considerations**, economic considerations, engineering realities, and political forces **balanced** during technological innovation?
    e. In what ways are technological needs and wants being **balanced** with long term environmental or social **consequences**?

9. how to **utilize** a variety of simple and complex **technologies**.
    a. How are technologies used to **control devices** and systems?
    b. How do technologies **communicate** with one another and provide information to humans?
    c. To what extent are technological systems and **devices controlled** by people and to what extent are they controlled by other technologies?
    d. How is technological **instrumentation** used to measure, calculate, manipulate, and predict the actions of technological devices and systems?

Construction Technologies

Inventor's Logbook

Name: Date: Activity:

What do we know and need to know to solve the Primary Challenge?

Place student questions here

Place student questions here

Construction Technologies

Students will understand:

Enduring Understanding 1: that technological progression is driven by a number of factors, including individual creativity, product and systems innovation, and human wants and needs.

e. What are the fundamental processes/principles used to develop new technologies?

Enduring Understanding 4: how technological systems work, the compoents of those systems, and how they fit into the larger technological, economic, and social systems.

a. What are the systems and subsystems involved in the various contexts of technology?

Enduring Understanding 7: that technological design is a systematic process used to initiate and refine ideas, solve problems, and maintain products and systems.

c. What design criteria is typically considered when developing new technologies (i.e., marketability, safety, useability, reliability, cost, materials, etc.) and how do these influence the final product/system design?
d. How are decisions made regarding information that should be discarded or ignored.
e. How can the attributes of design and the principles of design aid in the development of quality solutions?

Enduring Understanding 9: how to utilize a variety of simple and complex technologies.

d. How is technological instrumentation used to measure, calculate, manipulate, and predict the actions of technological devices and systems?

Teamwork Rubric

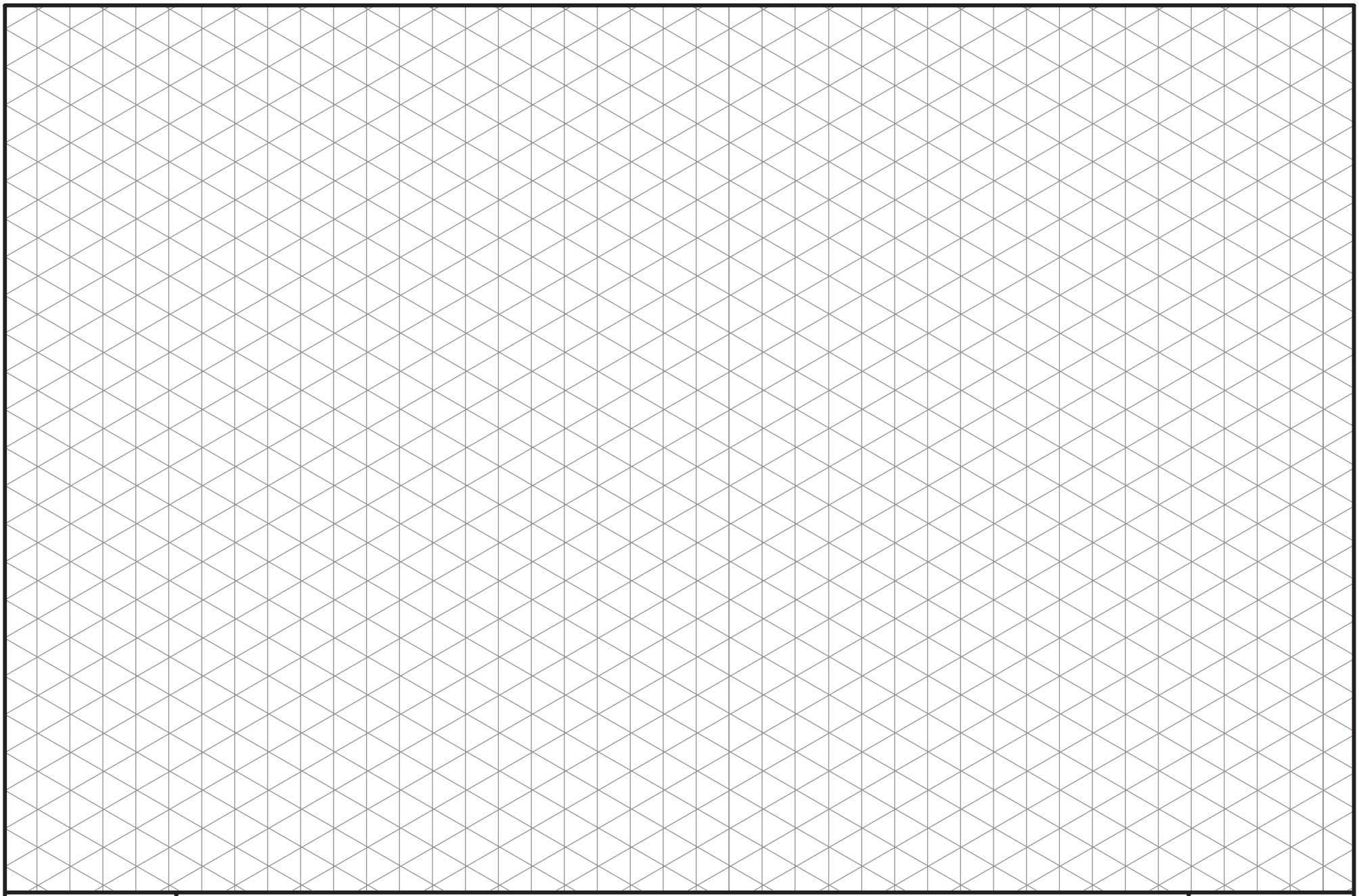
Observation of:	Criteria				Total Points
	4	3	2	1	
Helping - students offer assistance to one another	Consistently	Most of the time	Some of the time	None	
Listening - students work each others' ideas	Consistently	Most of the time	Some of the time	None	
Participating - students contribute to project/activity	Consistently	Most of the time	Some of the time	None	
Persuading - students exchange, defend, and rethink ideas	Consistently	Most of the time	Some of the time	None	
Questioning - students interact, discuss, and pose questions to all team members	Consistently	Most of the time	Some of the time	None	
Respecting - students encourage and support ideas and efforts of others	Consistently	Most of the time	Some of the time	None	
Sharing - students offer ideas and report their findings to each other	Consistently	Most of the time	Some of the time	None	
Collaborative - overall team work	Consistently	Most of the time	Some of the time	None	
				Total Points	

Additional comments:

General Discussion Rubric — Construction Technologies

Element	Criteria				Total Points
	4	3	2	1	
Interpretation - Understanding of issues, concepts, questions, ideas, topics	- Explores implications of issue and goes beyond it - Accurately states and identifies issues - Expresses relevant knowledge base based on own thoughts	- Explains aspects of issues - Accurately states issues - Expresses relevant knowledge base based on own thoughts	- Understands issues - States relevant factual, ethical, or definitional issue as a question -Expresses relevant knowledge base based on another's idea	- Does not state issues - Does not express relevant base knowledge	
Evidence - Support of comments	- Uses strong evidence relevant to specific issue - Draws connections with other relevant items and prior knowledge - Explains how it supports thoroughly	- Uses strong evidence relevant to specific issue - Explains how it supports	- Uses weak evidence relevant to specific issue - Briefly explains how it supports	- Does not provide evidence relevant to specific issue	
Listening and Responding - Commenting on others' ideas	- Invites comments from others - Compares own ideas to others' - Agrees/disagrees with specific parts and explains reasons - Reassesses own stance	- Invites comments from others - Explains reasons for agreeing or disagreeing - Adds to or challenges others' ideas	- Summarizes others' ideas - Agrees or disagrees with other ideas	- Only listens to others speak, does not respond - Copies other ideas - Disruptive	
Participation - Contribution to discussion	- Participates willingly - Takes a leadership role - Asks specific questions	- Participates willingly - Asks questions	- Participates only when called on	- Does not participate in class discussion	
				Total Points	

proBase	TITLE:		SCALE:
	DRAWN BY:	DATE:	ASSIGN:



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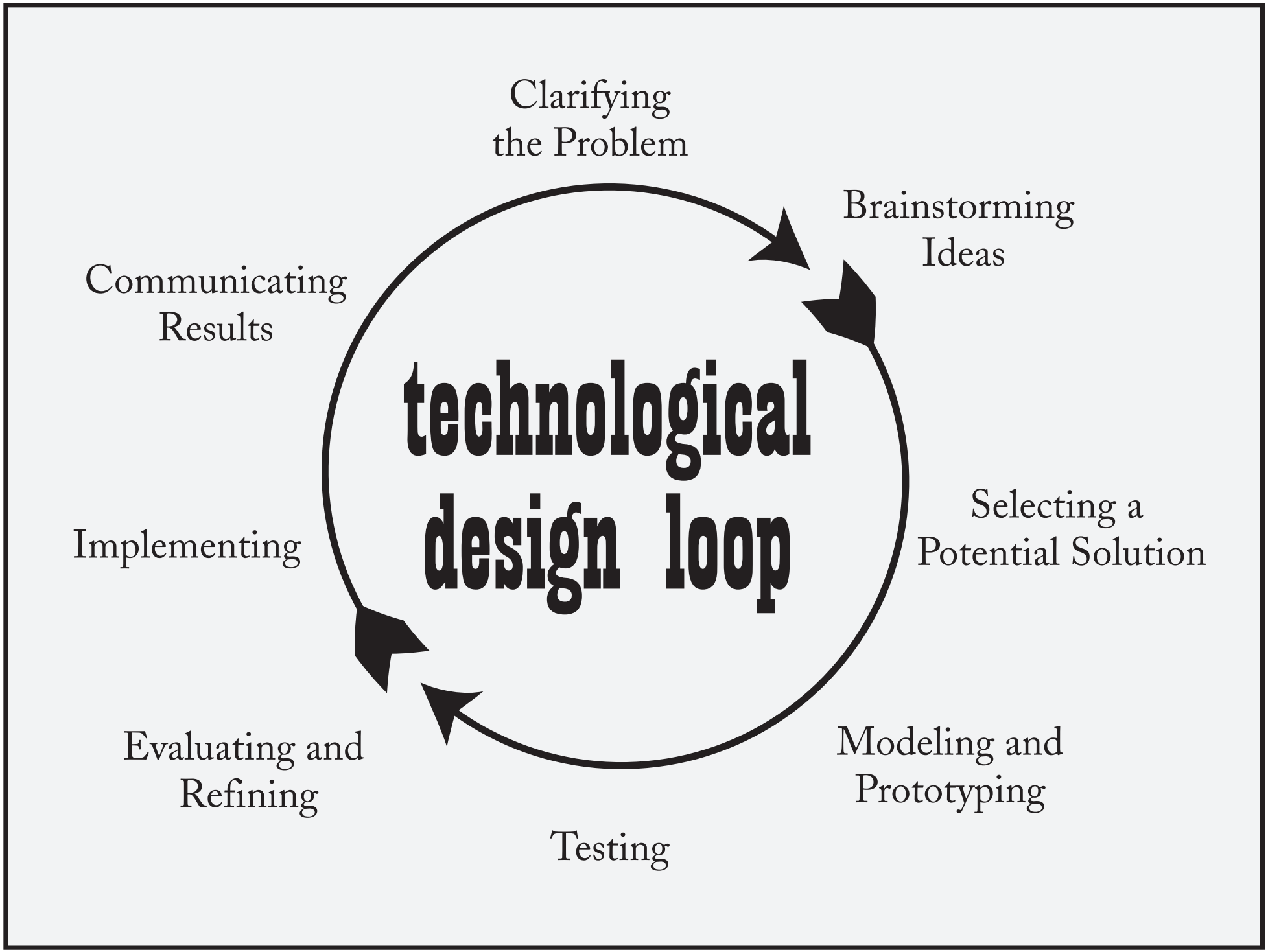
technological design loop
Clarifying the Problem
Brainstorming Ideas
Selecting a Potential Solution
Modeling and Prototyping
Testing
Evaluating and Refining
Implementing
Communicating Results

In addition to ***Construction Technologies***, the ProBase curriculum series offers seven other Learning Units. The eight ProBase units can be used independently, in conjunction, or as an entire curriculum package. A brief description of each of the ProBase learning units follows. For more information contact the Center for Advancing the Teaching of Technology and Science.

Energy and Power Technologies

This unit examines how energy and power systems can be made more efficient and how they may be utilized in problem solving. The unit also focuses on how modern energy and power systems impact cultures, societies, and the environment.

Medical Technologies

This unit provides an analysis of how medical technologies are used to increase the quality and length of human life, and how increased use of technology carries potential consequences, which require public debate. The tools and devices used to repair and replace organs, prevent disease, and rehabilitate the human body are also explored.

Agriculture and Related Biotechnologies

This unit provides an analysis of the various uses and ethical considerations of biotechnology. The unit also examines how agricultural technologies provide increased crop yields and allow adaptation to changing and harsh environments, enabling the growth of plants and animals for various uses.

Information and Communication Technologies

This unit examines how technology facilitates the gathering, manipulation, storage, and transmission of data and how this data can be used to create useful products. The unit also explores how communications systems can solve technological problems.

Entertainment and Recreation Technologies

This unit explores technological entertainment and recreation systems and how their use impacts human leisure-time performance. The social, cultural, and environmental implications of entertainment and recreation technologies are also examined.

Manufacturing Technologies

The unit explores the process of changing raw materials into finished products and how manufacturing affects the standard of living of various peoples. In addition, issues such as the maintenance of manufacturing efficiency, the effects of human consumption on manufacturing, and manufacturing's effects on the standard of living of various peoples are examined.

Transportation Technologies

This unit looks at the complex networks of interconnected subsystems that comprise transportation systems and the roles of these components in the overall functional process of transportation. The unit also provides an analysis of the improvements and the impacts of transportation technologies on the environment, society, and culture.