Preliminary and Primary Challenges

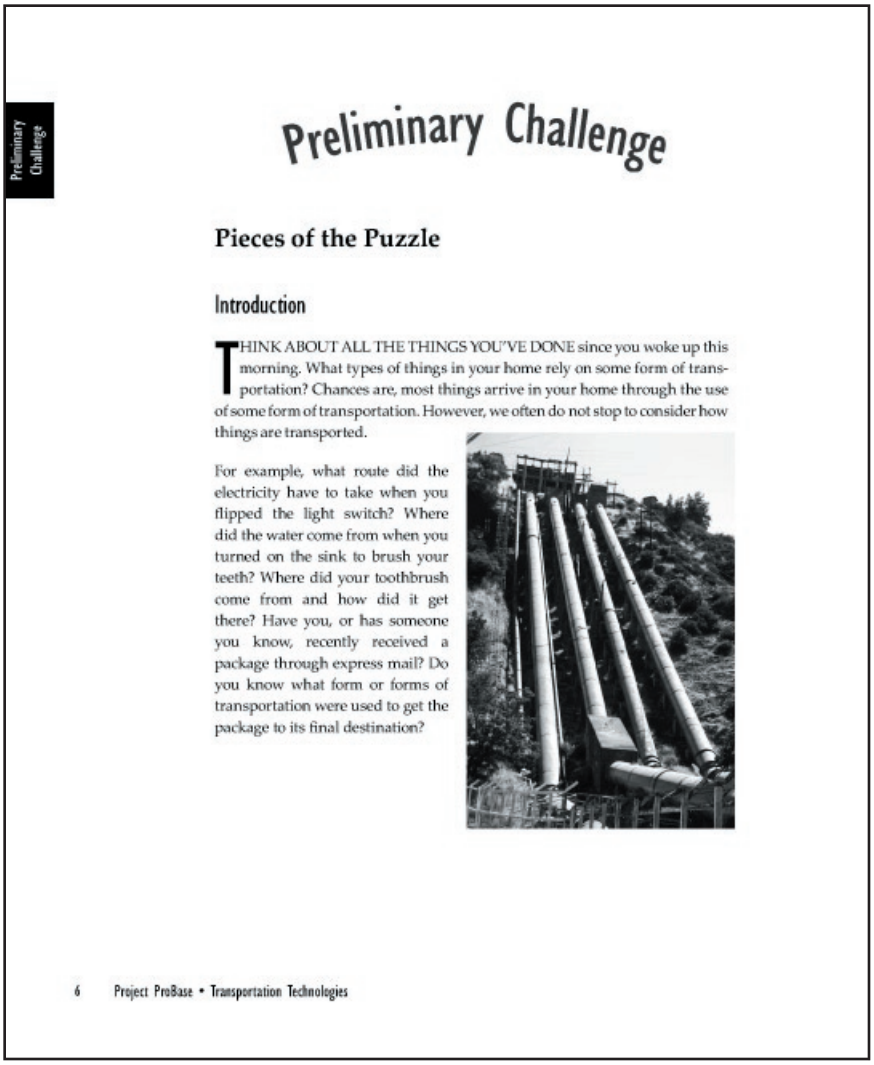
Pieces of the Puzzle

Introduction

The goal of the *Preliminary Challenge* is to get the students interested in learning about transportation technologies. It is designed to introduce the students to the four modes of transportation, which will be discussed following this introduction. Many students probably have the preconception that transportation involves getting into a car and driving. They probably do not consider that transportation can involve carrying any object, not just people, from one location to another and might sometimes include a stationary vehicle (such as a pipeline).

Defining the four modes of transportation (the students should come up with these on their own):

- Terrestrial - Transportation systems moving objects over land.
- Marine - Transportation systems moving objects on or through water.



Preliminary Challenge

Pieces of the Puzzle

Introduction

THINK ABOUT ALL THE THINGS YOU'VE DONE since you woke up this morning. What types of things in your home rely on some form of transportation? Chances are, most things arrive in your home through the use of some form of transportation. However, we often do not stop to consider how things are transported.

For example, what route did the electricity have to take when you flipped the light switch? Where did the water come from when you turned on the sink to brush your teeth? Where did your toothbrush come from and how did it get there? Have you, or has someone you know, recently received a package through express mail? Do you know what form or forms of transportation were used to get the package to its final destination?

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- Atmospheric - Transportation systems moving objects through the air, within the Earth's atmosphere.
- Space - Transportation systems moving objects outside of the Earth's atmosphere.

Preliminary Challenge

Team work

Perhaps you walked to school, rode the bus, or drove your car. These forms of transportation seem more obvious to us as we see them on a regular basis. Let's work in teams while taking a closer look at the broad modes of transportation.

Throughout this Learning Unit, you will be working in teams. Research has shown that teams can be more effective than individuals at solving complex problems. However, effective teams are not easily formed. Team members must work to understand each other. As a team member, you should know where your team is going and help to set goals for the team. All members of your team should strive to develop an open communication system where everyone can contribute. Each team member needs to assume responsibility and should be assigned to part of the project. Be patient and listen to your teammates.

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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 this Learning Unit. Each learning cycle is keyed to one or more of the following enduring understandings:

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.
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 to **evaluate** the benefits, limitations, and risks associated with existing and proposed technologies.
9. how to **utilize** a variety of simple and complex technologies.

Learning Unit Goal

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

Transportation is a controlled system that carries cargo from one location to another while protecting the cargo.

Equipment and Materials

Based on a class of 28 students:

Internet

Magazines (You could have the students bring in magazines from home.)

Scissors

Adhesive (glue, tape, etc.)

Colored Paper (16 sheets/group, 4 each of 4 different colors, a total of 112 sheets)

Facility Requirements

This activity can be conducted in any environment with ample space. When putting together the puzzle, the students will need a sizable (approximately 10′ x 10′) work area to put together their puzzle without interfering with other groups.

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

Suggested Daily Outline

Day One	Day Two
Introduction Puzzle work	Puzzle work cont'd.
Day Three	**Day Four**
Puzzle explanation *Reflection*	Introduction to the Primary Challenge

Preparing for the Preliminary Challenge

The goal of this Learning Unit is for the students to develop a working knowledge of the following concept:

To understand that transportation is a controlled system that carries cargo from one location to another while protecting the cargo.

Students should understand this statement in relation to the four modes of transportation.

Teaching Tips

It is suggested that you present this goal to the students before they begin working on their *Preliminary Challenge.* Although they are not expected to understand it in detail at this point, they need to become familiar with this material.

Throughout this Learning Unit, as well as other ProBase Learning Units, students will work in teams to accomplish tasks and solve problems. You may already encourage and require teamwork in some of your classes.

The main reasons for placing your students into teams is to help them better understand how and why team participation works, and for them to become more effective team members. Another purpose is to cause them to work together so that you can evaluate the teams and determine the best team configuration for the *Primary Challenge* work.

Studies show that teamwork:

- Makes a large task seem less daunting.
- Simulates and prepares students for a real-world work environment.
- Increases productivity.
- Allows students to get a different point of view on issues–each student brings something different to the work table.
- Increases knowledge–students learn from you, but they also learn effectively from their peers.

Teaching tips

Add some of the ideas listed above to the student-generated list. Explain why teamwork is important and describe how teamwork will be essential when completing the activities in this Learning Unit.

Teamwork promotes behaviors that might not be present in a larger class setting. It provides opportunities for participation for those students who normally would not speak up. It gives everyone the opportunity to contribute. It also teaches responsibility by holding the students more accountable for their learning.

Some points are worth discussing with the students:

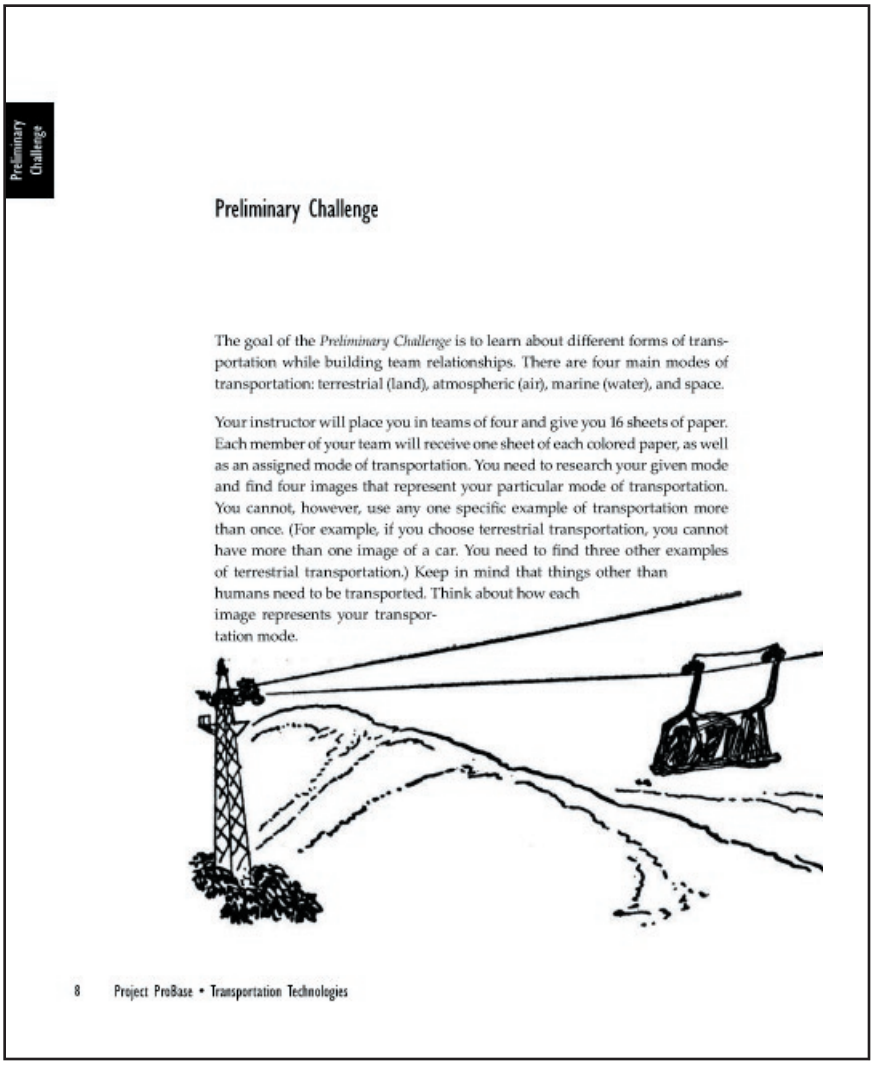
- Organization
- Inclusion, not exclusion
- Developing a plan of action

Place the students in groups of four and hand each student four sheets of each color of paper, (For example, one student receives a sheet each of yellow, green, blue and red.) Students should then research and find four images from their assigned mode of transportation.

As the students place their pieces together, remind them that:

- No two images from the same transportation modes can be in the same row or column.
- No two papers of the same color can be in the same row or column.

See example puzzle on the next page for a sample of the solution.



Preliminary Challenge

Preliminary Challenge

The goal of the *Preliminary Challenge* is to learn about different forms of transportation while building team relationships. There are four main modes of transportation: terrestrial (land), atmospheric (air), marine (water), and space.

Your instructor will place you in teams of four and give you 16 sheets of paper. Each member of your team will receive one sheet of each colored paper, as well as an assigned mode of transportation. You need to research your given mode and find four images that represent your particular mode of transportation. You cannot, however, use any one specific example of transportation more than once. (For example, if you choose terrestrial transportation, you cannot have more than one image of a car. You need to find three other examples of terrestrial transportation.) Keep in mind that things other than humans need to be transported. Think about how each image represents your transportation mode.

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Teaching Tips

The images needed for this challenge can be found in any type of magazine or on the Internet. If time permits, you may suggest that the students bring in magazines on their own. Images need to be adhered, attached, or printed on the colored sheets of paper. If you have a scanner or Internet access, you should encourage your students to use digital images for this activity. Make sure that all pictures are attached to the paper in the same way (portrait or landscape).

Preliminary Challenge

Once you have uncovered four different images representing your chosen mode of transportation, attach each image to a different piece of paper. Share your findings with your team members. Be prepared to discuss the results as a class.

Your team challenge, then, is to arrange all 16 images into one larger display (four sheets by four sheets). When completed, hang your team's display somewhere in the room. As a team, explain your display to the class.

There are two stipulations that your team must take into consideration while working through this process.

- No two images from the same transportation mode can be in the same row or column.
- No two papers of the same color can be in the same row or column.

T **red**	**M** **yellow**	**A** **green**	**S** **blue**
M **yellow**	**T** **red**	**S** **blue**	**A** **green**
A **green**	**S** **blue**	**T** **red**	**M** **yellow**
S **blue**	**A** **green**	**M** **yellow**	**T** **red**

Example puzzle solution

Preliminary Challenge key

T=terrestrial

M=marine

A=atmospheric

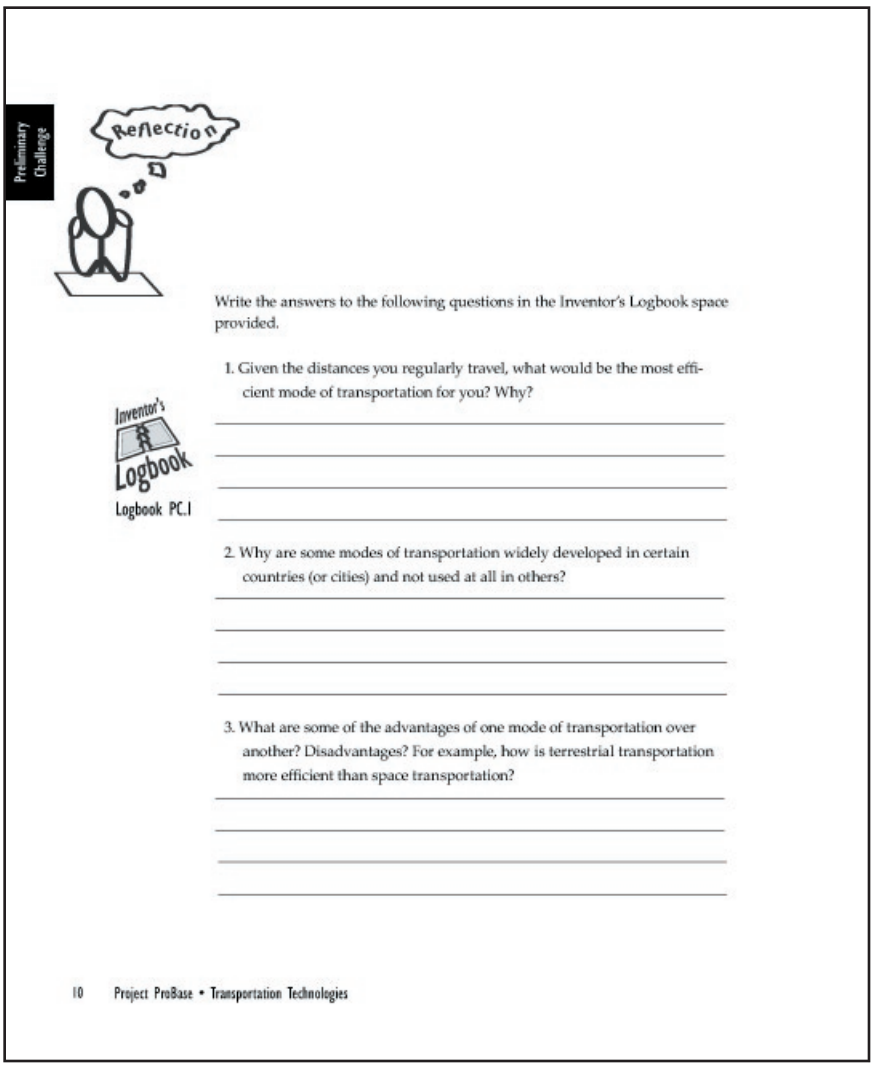
S=space

color name = paper color

Reflection

Review and discuss the *Reflection* questions and the Inventor's Logbook entries. Students should answer *Reflection* questions in the text in the Inventor's Logbook spaces provided. Responses will vary depending on class discussion.

1. Given the distances you regularly travel, what would be the most efficient mode of transportation for you? Why?
2. Why are some modes of transportation widely developed in certain countries (or cities) and not in others?
3. What are some of the advantages of one mode over another? Disadvantages? For example, how is terrestrial transportation more efficient than space transportation?



Preliminary Challenge

Reflection

Write the answers to the following questions in the Inventor's Logbook space provided.

Inventor's Logbook

Logbook PC.1

1. Given the distances you regularly travel, what would be the most efficient mode of transportation for you? Why?

2. Why are some modes of transportation widely developed in certain countries (or cities) and not used at all in others?

3. What are some of the advantages of one mode of transportation over another? Disadvantages? For example, how is terrestrial transportation more efficient than space transportation?

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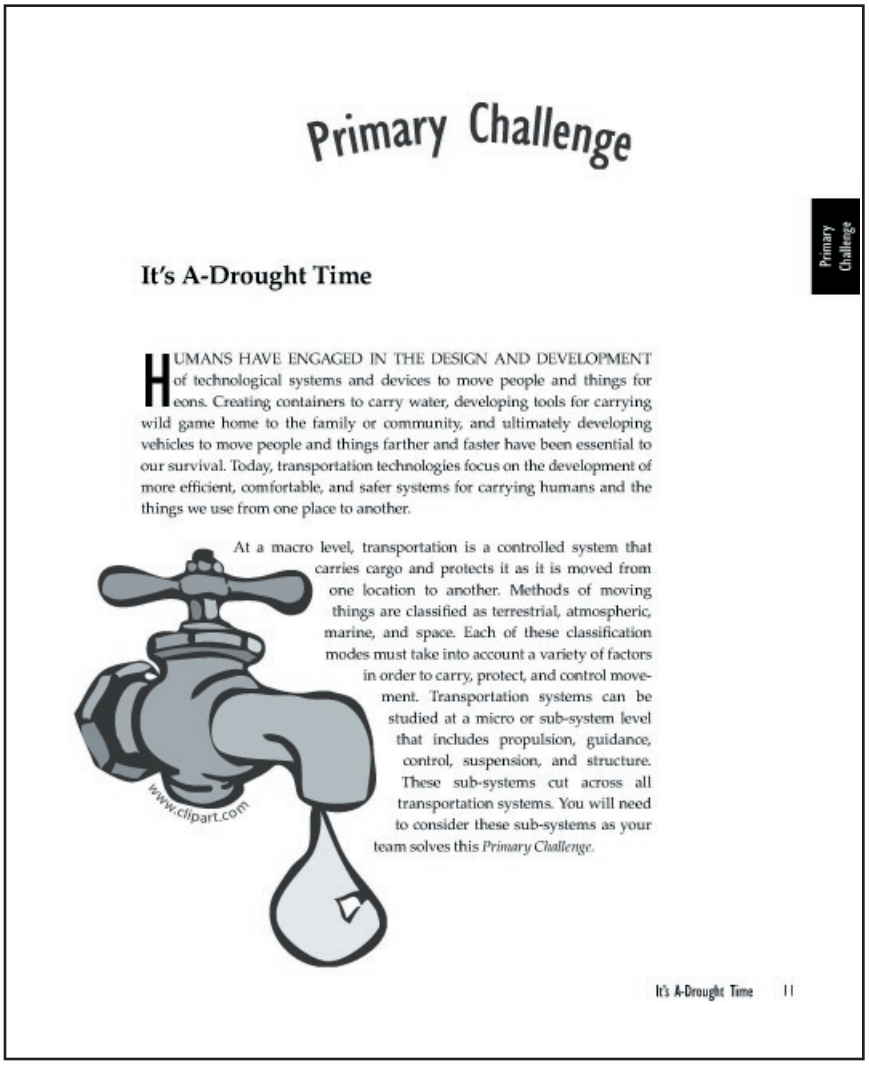
Facilitating Class Discussion

Once all of the puzzles have been put together, lead a class discussion on the different modes of transportation.

Teaching Tips

Groups should then explain their completed puzzle to the class. Some questions to think about as students present:

- Why did they choose a specific image?
- What were some of the challenges or difficulties that arose when completing the puzzle?
- How does a particular image represent a particular mode of transportation?



Primary Challenge

Primary Challenge

It's A-Drought Time

HUMANS HAVE ENGAGED IN THE DESIGN AND DEVELOPMENT of technological systems and devices to move people and things for eons. Creating containers to carry water, developing tools for carrying wild game home to the family or community, and ultimately developing vehicles to move people and things farther and faster have been essential to our survival. Today, transportation technologies focus on the development of more efficient, comfortable, and safer systems for carrying humans and the things we use from one place to another.

At a macro level, transportation is a controlled system that carries cargo and protects it as it is moved from one location to another. Methods of moving things are classified as terrestrial, atmospheric, marine, and space. Each of these classification modes must take into account a variety of factors in order to carry, protect, and control movement. Transportation systems can be studied at a micro or sub-system level that includes propulsion, guidance, control, suspension, and structure. These sub-systems cut across all transportation systems. You will need to consider these sub-systems as your team solves this *Primary Challenge*.

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Teaching Tips

Since the *Primary Challenge* probably looks overwhelming to your students, you will need to reassure them at this point. It is a good idea to make sure expectations are clear. Let students know that they will be provided with the necessary information to be successful. You could show them the unit calendar, pointing out the days reserved for work on the *Primary Challenge*.

You should also hand out the *Primary Challenge* rubric to give the students a clearer idea of what they will need to do. It is important for you to read the entire *Primary Challenge* section and understand the constraints for the challenge before discussing it with your students.

It's A-Drought Time

Introduction

The *Primary Challenge* should be introduced immediately after students complete the *Preliminary Challenge* so 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 two weeks are built into the schedule throughout this Learning Unit for students to work on the solution for the *Primary Challenge*.

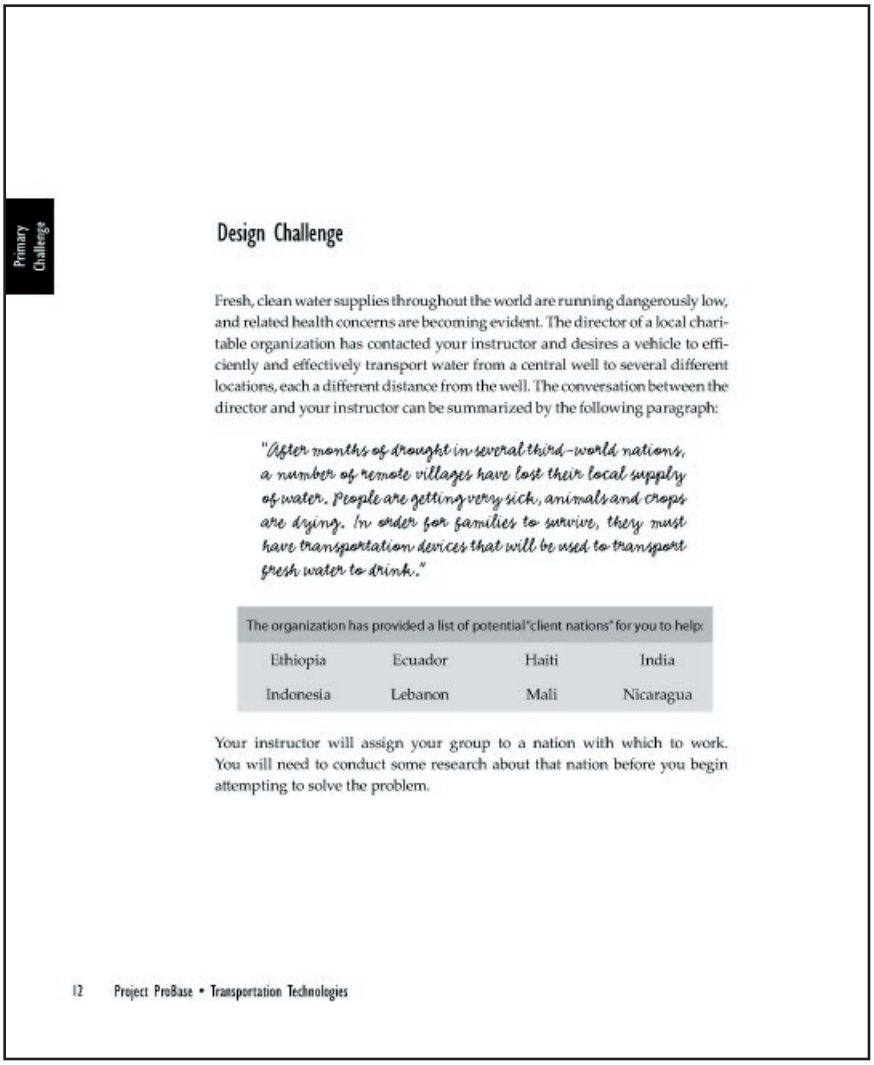
Students will be asked to reflect on this challenge and work on parts of their solution at the end of each learning cycle in a section titled *Preparing for the Challenge*.

Preparing for the Primary Challenge

The *Primary Challenge* requires the students to design and fabricate a transportation system that can travel over the terrain found in a particular country to several specified destinations while protecting cargo (water).

The students' solutions must incorporate sub-systems for propulsion, guidance, structure, support, and control. There will be learning cycles related to each of these concepts throughout the Learning Unit.

Estimated Number of 50-minute class periods: **15**
(throughout the Learning Unit)



Primary Challenge

Design Challenge

Fresh, clean water supplies throughout the world are running dangerously low, and related health concerns are becoming evident. The director of a local charitable organization has contacted your instructor and desires a vehicle to efficiently and effectively transport water from a central well to several different locations, each a different distance from the well. The conversation between the director and your instructor can be summarized by the following paragraph:

"After months of drought in several third-world nations, a number of remote villages have lost their local supply of water. People are getting very sick, animals and crops are dying. In order for families to survive, they must have transportation devices that will be used to transport fresh water to drink."

The organization has provided a list of potential "client nations" for you to help:			
Ethiopia	Ecuador	Haiti	India
Indonesia	Lebanon	Mali	Nicaragua

Your instructor will assign your group to a nation with which to work. You will need to conduct some research about that nation before you begin attempting to solve the problem.

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The students are given the following scenario:
Fresh, clean water supplies throughout the world are running dangerously low, and related health concerns are becoming evident. The director of a local charitable organization has contacted your instructor and desires a vehicle to efficiently and effectively transport water from a central well to several different locations, each a different distance from the well. The conversation between the director and your instructor can be summarized by the following paragraph:

"After months of drought in several third-world nations, a number of remote villages have lost their local supply of water. People are getting very sick, animals and crops are dying. In order for families to survive, they must have transportation devices that will be used to transport fresh water to drink."

- Think about the geography of the land–are there obstacles that you might have to cross?
- How are transportation systems designed and set up within the nation's borders?
- Will you need to overcome a language barrier when communicating your ideas? How will you do this?
- Assuming the citizens will be able to purchase the necessary materials in their home country, can you stay within the budget, especially with the varying currency exchange rates?

The director has asked your instructor to assist him in developing prototype transportation devices that would be capable of transporting set amounts of water over varying distances. On average, the nearest well is 25 miles (mi) away from the remote villages. However, some families may live as much as 40 mi from the wells.

The director recognizes that, as students of a technology class, you have the abilities, knowledge, and resources to take on the challenge to devise a vehicle to transport the water in an efficient and effective manner. Since money for travel costs is not available, you will have to complete your work locally. The director has asked that you design, construct, and test your vehicle in a simulated, scaled environment, and send the plans and a materials list to them so that the vehicle can be built on location in the selected third-world nation.

Teaching Tips

You will also need three containers to hold the water for this challenge. It is recommended that your containers be open at the top so that students are challenged to design a structure and support sub-system that prevents spillage. Buckets or empty coffee cans will work fine for this challenge. Let the students know the size of the containers before they begin designing their vehicles.

Teaching Tips

You will need to assign each team to one of the following nations:

Ethiopia, Indonesia, Ecuador, Lebanon, Haiti, Mali, India, or Nicaragua.

You should begin thinking about a possible location to have your students design a course for this challenge. It should be large enough so that your students can develop a scaled course with three distinct designation points. On average, the nearest well is 40 kilometers (km) away from the remote villages. However, some families may live as much as 60 km from the wells. Keep this in mind when locating an appropriate site for this challenge.

The student vehicles must:

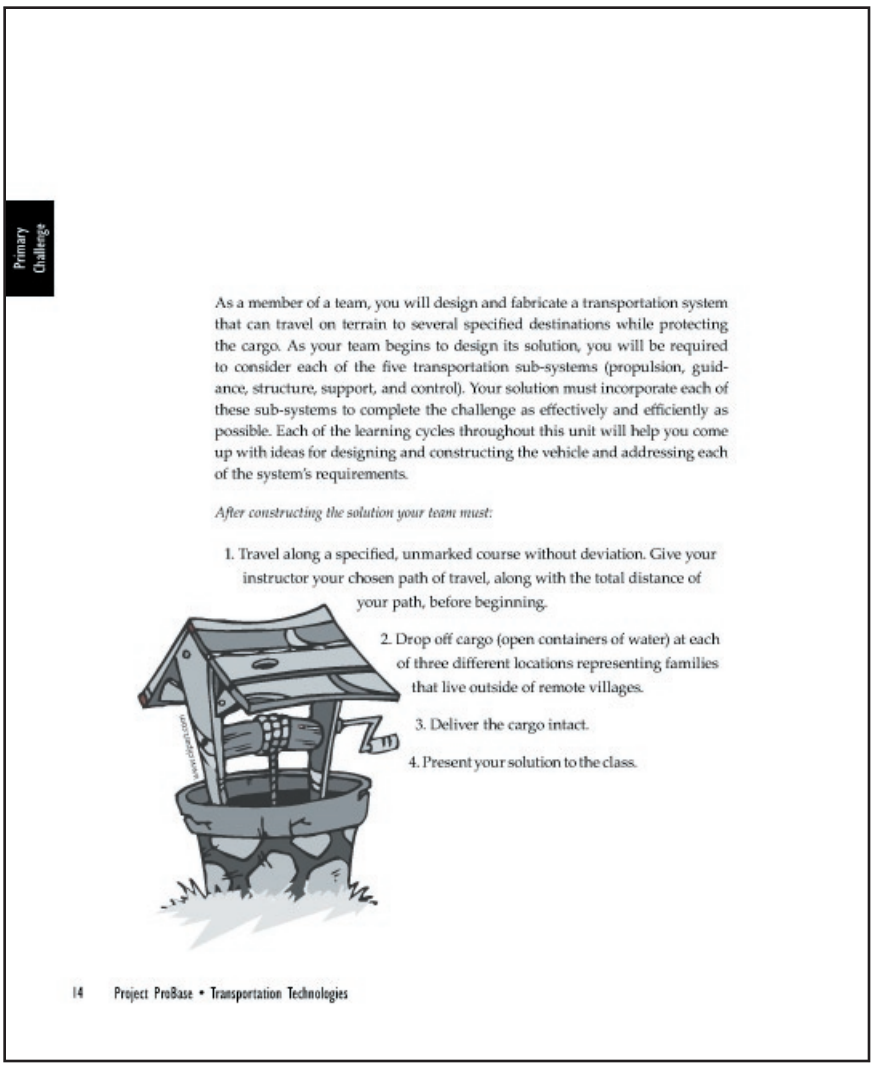
1. Travel along a specified, unmarked course without deviation. Students are asked to turn in to you their chosen path of travel, along with the total *distance* of their path. *They may use a GPS for this task, but it is not required.*

2. Drop off cargo (open containers of water) at each of the three locations.

3. Deliver the cargo intact. *Measure the amount of water spilled for each container. You could draw lines on the side of the buckets to measure amounts or weigh the bucket of water before and after the delivery.*

   You may want to take the amount of spilled water into consideration for the final results. A rubric for assessing their designed solutions is provided.

4. Students are also asked to present their solutions to the class. Presentations should include an explanation of each sub-system and describe how they worked together to carry, control, and protect the cargo.



Primary Challenge

As a member of a team, you will design and fabricate a transportation system that can travel on terrain to several specified destinations while protecting the cargo. As your team begins to design its solution, you will be required to consider each of the five transportation sub-systems (propulsion, guidance, structure, support, and control). Your solution must incorporate each of these sub-systems to complete the challenge as effectively and efficiently as possible. Each of the learning cycles throughout this unit will help you come up with ideas for designing and constructing the vehicle and addressing each of the system's requirements.

After constructing the solution your team must:

1. Travel along a specified, unmarked course without deviation. Give your instructor your chosen path of travel, along with the total distance of your path, before beginning.
2. Drop off cargo (open containers of water) at each of three different locations representing families that live outside of remote villages.
3. Deliver the cargo intact.
4. Present your solution to the class.

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During the presentation, students must:

- Deliver engaging, interesting, and informative presentations for other students.
- Share information about the geography of the country they were assigned and explain how the transportation system was designed for that country.

Your presentation should:

- Include an explanation of each sub-system and how they worked together to carry, control, and protect the cargo.
- Identify the constraints that your team faced and the trade-offs that were made throughout the design process.
- Share information about the geography of the country you researched and the transportation systems used in the country.
- Share how you plan to ship your design to your specified country and describe the path that will be used to get the cargo there.
- List the total vehicle and shipping costs in the appropriate currency.

Constraints/Requirements

- Each team will receive no more than $40.00 (U.S. dollars) for construction components, (See Table 1 on the next page. Any extra needed materials will have to be special-ordered from your instructor at an additional price determined by him or her.)
- Each vehicle must carry three containers of water, which may not be modified.
- Your vehicle must carry the cargo (water) and the driver.
- Once you climb into the vehicle, you cannot touch the ground with your hands or feet.
- Your team must complete the entire delivery process in a time determined by your instructor.
- A bicycle may be used in the construction of your vehicle, but not in its current configuration. The bicycle, if used, must be reconfigured to have three or four wheels (arranged in a manner similar to modern vehicles), a different steering system, and a different drive train.

Primary Challenge

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Teaching Tips

Remind students to talk about each of the sub-systems, ways they implemented the sub-system, and how they arrived at a solution to the *Primary Challenge*.

One of the constraints states that each student team must complete the entire delivery process within a time determined by the instructor. You will need to determine an appropriate time based on your course and students' abilities. It is recommended that you let your students decide an appropriate time limit as a class once the course has been identified.

Primary Challenge

- Outline plans for shipping solutions to the specified country, identify the route intended for shipping the cargo, and provide an estimate of shipping costs using appropriate currency.

Encourage students to use appropriate presentation techniques such as maps, computer generated images, and presentation software during their presentations. A rubric for assessing their presentation is provided.

Teaching Tips

The constraints specify that the solution must carry the driver while carrying three open containers of water. One container of water will be dropped off at each of the three sites and a different member of the team must be transported to the next location. The constraints do not specify the route that each team must travel. This is left to each team's discretion. Because there are multiple plausible paths for this solution, each team should give you its selected path before beginning.

Materials	Cost per item (in U. S. dollars):
2" PVC pipe (10 ft. length)	3.00
1.5" PVC pipe (10 ft. length)	2.50
90° Elbow (2")	.70
90° Elbow (1.5")	.60
45° Elbow (2")	.70
45° Elbow (1.5")	.60
Straight T (2")	1.20
Straight T (1.5")	1.00
Y (2")	1.25
Y (1.5")	1.00
Coupling (2")	.55
Coupling (1.5")	.40
4 Wheels	10.00
2 Axles	3.00

Table 1. *Materials pricing list*

Note: Your instructor may modify this list or the requirements for this *Primary Challenge*. Make sure you understand the requirements for your solution before beginning your design.

Teaching Tips

As you present this *Primary Challenge* to your students and discuss their questions, you should highlight how important it will be for them to design a structure that will support the weight of the heaviest person on their team. If this is problematic for your students, there are several ways to work around this issue. One suggestion is to have students from a lower grade level participate in the task by driving the vehicles. Another solution is to increase the diameter of the PVC pipe. This will reduce the flex of the pipe. The flex can also be reduced through a structural design that incorporates multiple triangles. Another suggestion is to incorporate an old bicycle into their designs. However, if students choose to incorporate a bicycle, remind them that the bicycle cannot be used in its current configuration.

Materials	Cost per item (in U. S. dollars):
2" PVC pipe (10 ft. length)	3.00
1.5" PVC pipe (10 ft. length)	2.50
90-degree elbow (2")	.70
90-degree elbow (1.5")	.60
45-degree elbow (2")	.70
45-degree elbow (1.5")	.60
Straight T (2")	1.20
Straight T (1.5")	1.00
Y (2")	1.25
Y (1.5")	1.00
Coupling (2")	.55
Coupling (1.5")	.40
4 wheels	5.00
2 axles	3.00

Table 1. *Materials pricing list*

Facility Requirements

The construction of the students' solutions can be completed in a regular lab setting. However, the testing of the students' solutions will need to be conducted in a large space, such as the school's gymnasium or cafeteria, or outside.

Equipment and Materials

Based on a class of 28 students:

The materials and equipment needed will vary according to the students' solutions to this challenge. In an effort to vary the solutions and challenge the students to consider trade-offs during their development work, a list of materials and their costs in U.S. dollars is provided in the student edition. PVC was selected as a construction material because it is readily available in most communities, offers a high weight to strength ratio, is easily worked with using common tools, and comes in a variety of sizes and shapes of connectors.

Student teams will be required to submit a materials list prior to constructing their solutions. Their list should show both U.S. dollars and the currency used by their country. It is recommended that you purchase one of each item on the list so that the students can see and touch each part as they design their solutions.

If a bicycle is not easily obtainable, encourage students to brainstorm other freely obtainable materials and objects. Remind them that their solution will have to be reproducible in another nation, so that might limit the use of some materials.

Teaching Tips

After going through the *Preliminary Challenge* and introducing the *Primary Challenge*, you will need to divide your class into teams. After observing students during the *Preliminary Challenge*, you should have a better idea of which combinations of students will make the most effective teams.

Teaching tips

After you have assigned teams and specified their "nation," each team will need some time to work together. Some of the task can be assigned as homework; however, it is recommended that you provide one class period at this time for teams to begin working together on the following task:

> Have students conduct work on their assigned country. They should be looking for, the terrain native to the country as well as the currency exchange rate. The currency exchange rate fluctuates regularly. Therefore, you will need to assign a date for each team to use as a basis for calculation. An alternative that would sharpen students' mathematics skills would be to have them use an average exchange rate taken over a specified period of time. This would require that students look for the exchange rate daily and then find the mean rate for the specified length of time.

A larger version of the materials and cost table (***Table 1***) is found on the previous page.

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 entries will serve as one means to check their 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 a list of questions that must be answered in order to solve the challenge. Create a large class display that lists these questions and require the students (or teams) to "check off" the questions that have been answered during the course of the Learning Unit. This has been found to be very helpful in our test sites.
- Have your students create concept maps of the unit. This can be done individually or in small teams.

Primary Challenge Rubric

Element	Criteria				Points
Point Values	40	30	20	10	
Primary Challenge Product	Completed product is fully functional and addresses all criteria, parameters, and equipment specifications set forth in the *Primary Challenge*.	Completed product is functional and meets most criteria, parameters, and equipment specifications set forth in the *Primary Challenge*.	Completed product represents a serious attempt to solve the *Primary Challenge*, but does not address many of the stated criteria, parameters, or specifications.	Product is not complete or does not function well and does not meet stated criteria, parameters, or specifications.	
				Sub-total	
Point Values	15	10	5	2	
Drawings, Diagrams, & Sketches	Drawings, diagrams, or sketches clearly illustrate an understanding of all requirements, criteria, or specifications; uses proper format; and was completed electronically.	Drawings, diagrams, or sketches illustrate needed information, but do not address all stated requirements, specifications, or criteria. Completed using an electronic format.	Drawings, diagrams, or sketches illustrate needed information, but do not address all stated requirements, specifications, or criteria. Did not utilize an electronic format (hand drawn).	Drawings, diagrams, or sketches do not illustrate all needed information. Illustrations are incomplete or poorly presented.	
Research & Development	Clear evidence of a comprehensive research and development effort was provided.	Research and development was conducted while solving the primary challenge, but documentation was marginal.	Some research and development techniques were used while attempting to solve the *Primary Challenge*, but were not clearly documented.	Minimal research and development techniques were used while attempting to solve the *Primary Challenge*. Documentation was marginal.	
Documentation	As directed, the team responded to questions and/ or maintained comprehensive records, logs, and other notations of activities while completing the *Primary Challenge*.	Team responded to questions and/or maintained topical records, logs, and other notations of activities while completing the *Primary Challenge*.	Team responded to most questions and/or maintained some records, logs, and other notations of activities while completing the *Primary Challenge*.	Team marginally responded to questions and did not maintain records, logs, and other notations of activities while completing the *Primary Challenge*.	
Presentation	Presentation demonstrates a full grasp of the major concepts, addresses all stated presentation 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	