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Guidebook for Railway-themed K-12 STEM Outreach Activities

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Introduction

Welcome to the *Guidebook for Railway-themed K-12 STEM Outreach Activities*! Inside, you will find descriptions of educational activities designed to introduce students to the railroad transportation mode through the lens of STEM (Science, Technology, Engineering, and Mathematics) concepts.

Railroads have been a critical part of the global economy since the 1830s. Today, railroads haul more ton-miles of intercity freight (one ton of freight moved one mile) than any other mode of transportation in the United States. While the railroad industry is the leader in long-haul freight transportation, recruiting students to leadership roles in the industry is challenging. With many railroad employees approaching retirement age, the need to raise student awareness of railway industry career opportunities has never been greater.

The activities in this guidebook cover a wide variety of railroad topics. The activities are intended to be hands-on to provide students with knowledge through experiential learning that also increases their awareness of railway transportation technology. Although the following chapters provide a step-by-step guide to each activity, we encourage you to experiment with modifications to each activity and to create your own activities on other facets of the railroad industry and STEM topics.

We hope you find the activities in this guidebook to be informative and entertaining!

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Intermodal Transportation Game

This activity compares the efficiency of intermodal freight transportation using trucks and rail to the efficiency of truck-only transportation.

Number of Participants: 2 (minimum) **Recommended Age:** 5+

Setup Time: 10-25 minutes **Activity Time:** 10 minutes

STEM Concepts:

- *Technology: containers allow intermodal shipments to use multiple transportation modes*
- *Engineering: different modes of transportation are more efficient at certain tasks and combining them through intermodal service can increase overall efficiency and performance*

Key Learning Points

1. **Containers are designed to be transported by truck, rail, and marine transportation.**
2. **Intermodal transportation can be more effective than transportation by a single mode.**
3. **Railroads are more effective for long-haul and high-volume transportation than trucks.**

Background

Intermodal transportation is the movement of products using multiple types of transportation such as land, sea, air and water, also known as “transportation modes”. Typically, in the context of North American freight rail transportation, intermodal transportation is the movement of products loaded into containers via at least two of truck, rail, or marine (ship or barge) transportation.

Intermodal transportation takes advantage of the strengths of each transportation mode. For example, ships can transport a large number of containers at a low cost but are limited to oceans and some inland waterways. Railroads can transport large volumes of freight over land at a low cost but are usually unable to provide door-to-door service to many shippers and customers. Trucks are capable of providing door-to-door service but are most effective at transporting smaller volumes of freight over shorter distances. By using each of these modes where they are most effective in the routing of a container, a shipper gets the best service and typically at a lower cost. The goal of the Intermodal Transportation Game is to demonstrate how intermodal transportation using rail and truck provides more effective service than trucks as a single mode of transportation.

Figure 1: A typical intermodal train

Figure 2: A truck carrying an intermodal container

Figure 3: A loaded container ship

Figure 4: Containers being transloaded from ship to truck chassis at a port intermodal terminal

Figure 5: Transloading containers from railcars to truck at a rail intermodal terminal

Materials List and Setup

Materials:

The Intermodal Transportation Game requires the following components:

- Playing board
- 12 containers
- 2 three-car trains
- 2 trucks
- 1 container ship

The playing board serves as a surface for the truck and rail vehicles to transport containers between a "container ship" and a container yard. A primary function of the board is to define the routes for the trains and trucks to follow. The game is designed to cover two folding tables placed end to end. There are several options for playing board materials such as:

- Plywood boards with balsa wood strips to define the railway
- Foam core boards with hand drawn road, track, container ship and container yard areas
- Long roll of paper with features drawn or printed on a roll plotter (can also be laminated)
- Masking tape routes directly on table tops

There are several options for creating the trucks and trains.

- Pinewood derby car kits (available through Amazon, Scout Shops, and a variety of retail stores including Hobby Lobby) can be used to create the truck, the locomotive and each railcar in the train. Metal hooks or hooks and eyes can be screwed into the ends of the railcars and locomotive to act as couplers.
- Containers can be represented with wooden blocks sized appropriately to be carried by the truck and railcars. The containers can have magnets embedded on both the top and bottom of them so that they will stick together when stacked on the train. An additional magnet can be embedded on the train cars and trucks to make the containers stick to the train car or truck. Wooden pegs and dowels with appropriate holes in the containers can also be used to facilitate stacking and holding containers in place on the trucks and railcars.
- LEGO vehicle kits and train kits can also be used for the various vehicles and to build boxes to serve as containers.

The "container ship" serves as an area where the containers are stacked at the start of the game. The ship can be a platform fabricated from scraps of wood, or simply a representation of the ship drawn, printed or painted on the playing board. The ship should have some separation to divide the containers into two separate groups of stacks, one for each of the two players.

The container yard or stacking area is where the containers end up at the conclusion of the game. Specific spots for each stack of containers should be designated with colored squares or outlines in the container stacking area. Ideally the container spots are coded with colors or letters to match certain containers. Two containers should be designated for each stacking point in the container yard.

Setup (Plywood Board with Pinewood Derby vehicles):

This setup uses a playing board made from four plywood sections supported by tables. Each section is 40 inches wide by 48 inches long. The railway track is represented by thin strips of balsa wood sticks spaced so that the pinewood derby wheels of the locomotive and railcars run between them.

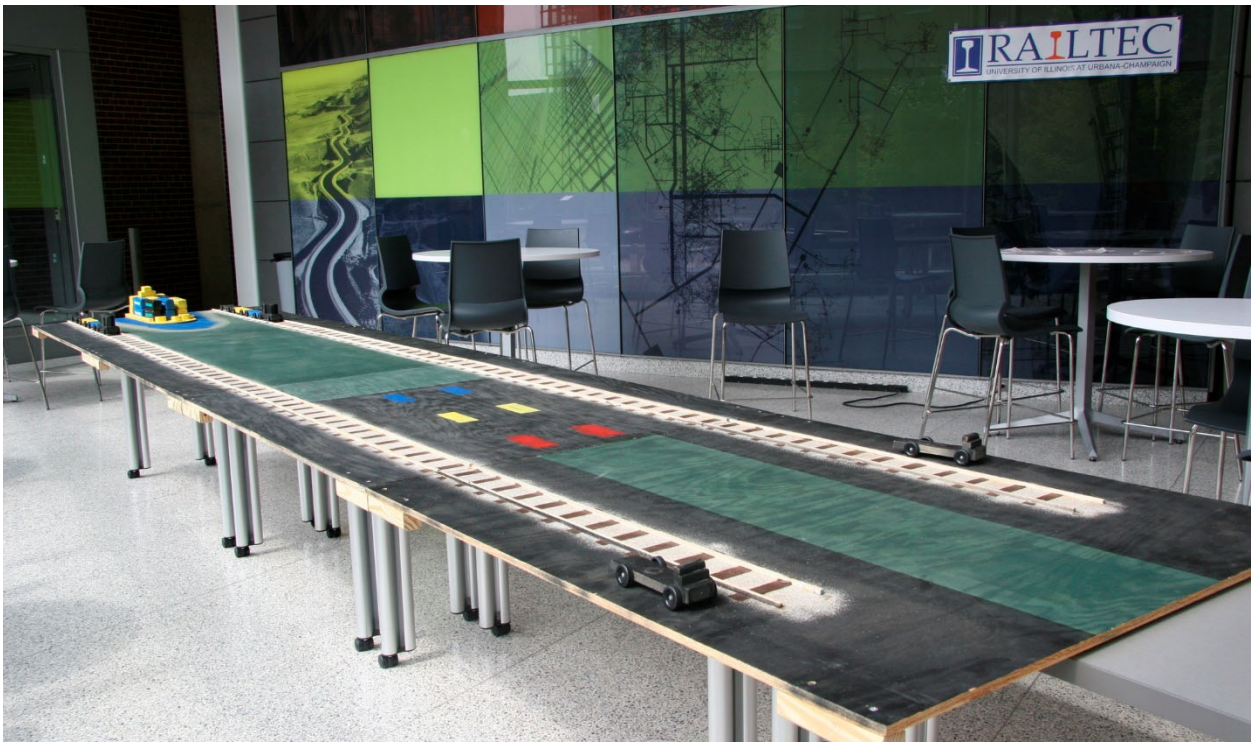

Figure 6: Intermodal Game Board

Figure 7: Trains and Container Ship

Playing the Game

Rules:

1. There are two rounds with the same two participants in each.
2. The objective of the game is to be the first player to deliver six containers from the container ship to the container yard.
3. Each train is one locomotive plus three cars. Each car can carry two containers (one stacked on top of the other), so one train can handle six containers total.
4. A truck can only handle one container at a time.
5. The containers should be color coded so that they have a designated spot in the container yard.
6. The vehicles must follow the paths shown in Figure 7. Note the position of Truck 1 adjacent to where Train 1 stops for transferring of containers from train to truck. Truck 1 must return to this spot from the container yard before it can be loaded with another container from the train. Note that Truck 2 must drive all the way around the end of the track before heading to the container yard… no shortcuts!
7. For the first round, one player will use a combination of Train 1 and Truck 1 to deliver their six containers, while the other player will only use Truck 2 to deliver their containers.
8. For the second round, both players can use any combination of their train and truck to deliver the containers.
9. Both players should be told that they may only handle one container at a time (enforced by placing one hand behind their back at all times) and that **they may not run**.

In Figure 7, for the first round, the path for Player 1 is shown by the red arrow, while the path for Player 2 is shown by the blue arrow. In round two, each player may use a combination of these paths.

Theoretically, Player 1 (truck and train) should win the first round. This is the purpose of the game because it shows how combining trains and trucks to deliver freight is more efficient than only using trucks. Player 2 is at a disadvantage because trucks do not have the capacity to move large amounts of freight at once. Player 1 is able to take advantage of that capacity, which gives them an advantage.

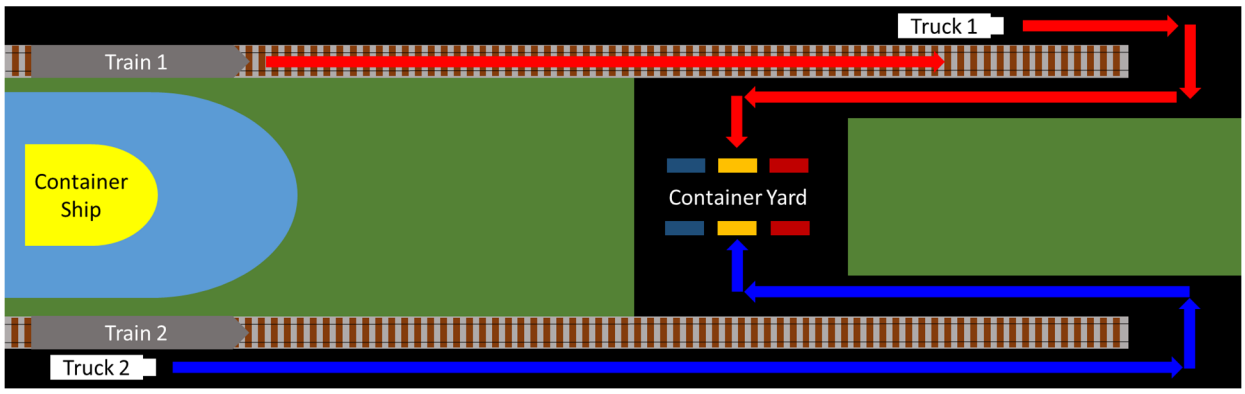

Figure 8: Intermodal Game board layout

The second round is mostly the same as the first round except that Player 2 is allowed to use Train 2 and Truck 2 to deliver their containers in the same way that Player 1 was allowed to use both Train 1 and Truck 1. This round evens the playing field so that Player 2 has a reasonable chance of winning. If you are short on time or the players do not wish to continue, this round may be skipped.

Extending the Game:

Option 1: Changing Shipment Distance

To demonstrate the influence of distance on the relative competitiveness of truck and rail, extend or shorten the overall length of the playing board to increase or shorten the truck and rail trip.

- Lengthening the board to force the truck to make many long trips should favor the train.
- Shortening the board may make the truck more competitive as it can quickly make multiple trips while the train is being loaded.

Option 2: Changing Shipment Volume

To demonstrate the influence of shipment volume on the competitiveness of truck and rail, have the players both ship an additional pair of containers (this also requires one additional car to be added to the train), or only ship four containers instead of six.

- Increasing the number of containers forces the truck to make many more trips and should favor the train.
- Decreasing the number of containers may make the truck more competitive as it can quickly make multiple trips while the train is being loaded.

Questions to Stimulate Student Thought

1. Other than a shorter transit time for freight, what benefits can intermodal transportation bring?
2. What haul length (short-haul or long-haul) do each of the transportation modes (train, truck, ship) excel at? Why?

Adjusting for Time and Participant Age

1. The activity may be shortened by eliminating the second round since the first round demonstrates the effectiveness of intermodal transportation. The second round functions solely as a “consolation round” to give each player an equal chance at winning.
2. The activity can be lengthened by repeating the first round except the participants will swap roles. In other words, the participant who used only the truck for the first round will use the train and truck for the second round, and the participant using both the train and truck for the first round will only use the truck for the second round. A third round where both participants use both the train and truck can also be played.
3. For older participants, ask them to predict which method is more effective before playing the first round of the game. Then play the game and discuss why their predictions were correct or incorrect.