



National University Rail Center - NURail
US DOT OST-R Tier 1 University Transportation Center

NURail Project ID: NURail2014-UIUC-E09

Guidebook for Railway-themed K-12 STEM Outreach Activities

By

C. Tyler Dick, Ph.D., P.E.
Lecturer and Principal Research Engineer
Rail Transportation and Engineering Center (RailTEC)
University of Illinois at Urbana-Champaign
ctdick@illinois.edu

Lee Evans
Graduate Research Assistant
Rail Transportation and Engineering Center (RailTEC)
University of Illinois at Urbana-Champaign
leonele2@illinois.edu

23-12-2020

Grant Number: DTRT13-G-UTC52 (Grant 2)

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!

Acknowledgements

This guidebook was made possible by the financial support of the following organizations:

- National University Rail Center (NURail), a U.S. DOT OST Tier 1 University Transportation Center
- National Railroad Construction and Maintenance Association



The authors would also like to acknowledge the following individuals and organizations for their contributions to this guidebook:

- Christopher Barkan, Rail Transportation and Engineering Center (RailTEC), University of Illinois at Urbana-Champaign
- Pasi Lautala and Dave Nelson, Rail Transportation Program, Michigan Technological University
- Bryan Schlake, Rail Transportation Engineering Program, Penn State Altoona
- Dimitris Rzos, Advanced Railroad Technology Group, University of South Carolina
- Members of American Railway Engineering and Maintenance-of-Way Association (AREMA) Committee 24 - Education and Training
- LB Frye, and faculty, staff and students with RailTEC, University of Illinois at Urbana-Champaign
- Members of the AREMA Student Chapter at the University of Illinois at Urbana-Champaign
- Students and staff at the Next Generation School, Champaign, Illinois

Edible Railroad Track Construction

Build your own section of “railroad track” from the subgrade up to the rails using cereal and candy!

Number of Participants: 2 or more

Recommended Age: 3+

Setup Time: 0 minutes

Activity Time: 10 minutes

STEM Concepts:

- *Science: pressure is the amount of force applied over a given area*
- *Technology: track is a structure designed to support the weight of railway rolling stock*
- *Engineering: track components reduce pressure by distributing forces over a greater area*
- *Mathematics: measuring materials and fractions*

Key Learning Points

1. **Understand the basic components of railroad track (rail, ties, ballast) and their purpose.**
2. **Track components take very high forces and gradually spread them out over a large area.**
3. **Track ballast is effective at resisting lateral and longitudinal forces.**

Background

Railroad track is designed to support the weight of heavy locomotives and railcars moving at speed. The components of the track structure must be able to resist large forces created by trains in both the vertical and lateral directions:

- Rails guide the train wheels and transfer their weight across multiple crossties.
- Crossties (also simply called “ties”) support the rails, hold them the proper distance apart, and distribute the weight of the train over a larger area, reducing pressure on the ground below.
- Ballast, the crushed rock gravel that is underneath and between the crossties, supports the crossties, and provides resistance to the forces created by the train.

This activity demonstrates the effectiveness of ballast at restraining the track and helps the participants understand the different components of track and their purposes.

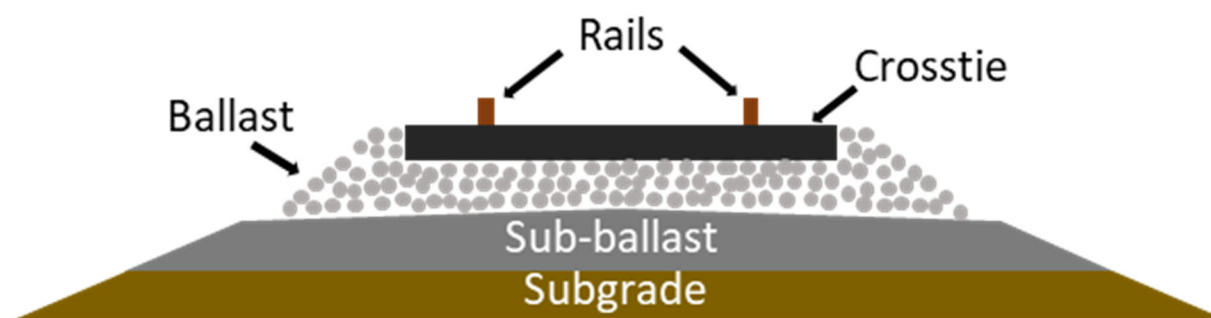


Figure 1: Typical railroad track cross-section showing the main components of the track structure

Materials List

Materials:

- The following materials and quantities are required for each participant to build their own edible track structure model:
 - Paper plate
 - Kit Kat bars (2 snack size bars)
 - Twizzlers twists (2 – fun size pieces)
 - Rice Krispies Cereal (1/4 cup)
- Royal icing (optional)
- These materials (Figure 2) are most economically obtained in bulk to cover multiple participants.



Figure 2: Recommended materials

Script

1. Construct the skeleton track (track without ballast) by spacing out the “ties” (two Kit Kats snapped in half to form four pieces) on the paper plate “subgrade” and laying “rail” (Twizzlers) on top of them. For best results, construct a track that is approximately 4-6 inches long (Figure 3).



Figure 3: Skeleton track

2. Optionally, put a dab of royal icing between the rail and each crosstie to secure the connection. After the icing hardens, try sliding the track side-to-side without lifting it off the plate. There will be little resistance to movement. This is not ideal for real track as it could cause a derailment!
3. Next, cover the track with Rice Krispies cereal (1/4 cup for the length shown in Figures 3 and 4). This represents the ballast (stone) that covers real railroad track and helps prevent the track from moving around underneath a train.



Figure 4: Ballasted track

4. After adding ballast, try moving the track side-to-side again. You should notice that it takes more force to move the track since you also must displace the “ballast” around the crossties. Real ballast serves this same purpose: to resist lateral and longitudinal movement of the track.
5. Enjoy your railroad track snack!