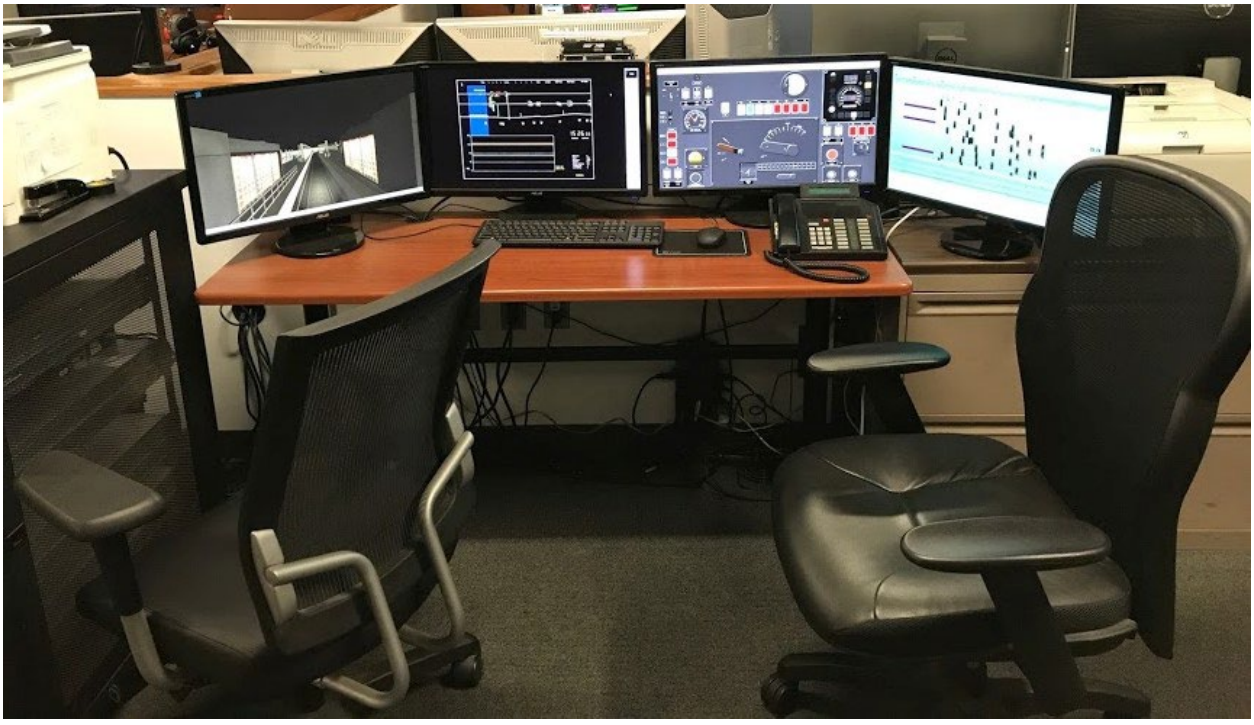
U.S. Department
of Transportation
Federal Railroad
Administration

Office of Research,
Development and Technology
Washington, DC 20590

Evaluation of Scenario-Based Training for Railroad Transportation Employees



DOT/FRA/ORD-23/05

Final Report | February 2023

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof. Any opinions, findings and conclusions, or recommendations expressed in this material do not necessarily reflect the views or policies of the United States Government, nor does mention of trade names, commercial products, or organizations imply endorsement by the United States Government. The United States Government assumes no liability for the content or use of the material contained in this document.

NOTICE

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the objective of this report.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.
PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
February 10, 2023	Technical Report	May 2019 – September 2022

4. TITLE AND SUBTITLE
Evaluation of Classroom Centered Scenario-based Training for Railroad Transportation Employees

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Jared Young, ORC ID 0000-0001-9502-3632
Jordan Multer, ORC ID 0000-0002-7818-110X

5d. PROJECT NUMBER
RR04AB/VK297

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Volpe National Transportation Systems Center
55 Broadway
Cambridge, MA 02142

8. PERFORMING ORGANIZATION REPORT NUMBER
DOT-VNTSC-FRA-22-03

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Department of Transportation
Federal Railroad Administration
Office of Railroad Policy and Development
Office of Research, Development and Technology
Washington, DC 20590

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
DOT/FRA/ORD-23/05

12. DISTRIBUTION/AVAILABILITY STATEMENT
This document is available to the public through the FRA website.

13. SUPPLEMENTARY NOTES
COR: Michael Jones

14. ABSTRACT
In 2015, a peer review team (PRT) comprised of labor, craft employees, and railroad managers developed railroad scenario-based training (SBT). The PRT was responsible for reviewing close call reports and developing recommendations to address unsafe conditions on the railroad. The objective of SBT is to improve the coordination of teams to operate safely through exposure to the hazardous conditions that can lead to unsafe outcomes that railroads previously identified through observations, close call reports, incident reports, and accidents. The research evaluated the effectiveness of SBT to learn if the training is contributing to more effective learning of safety-critical behaviors. Among the three railroads that were able to conduct training sessions, each demonstrated that SBT can lead to slight improvements in students' correct responses on training evaluation forms. While the differences in pre- and post-evaluation forms were not significantly different for experienced employees, new employees displayed just under 17 percent improvement, which was statistically significant. This significant difference shows that SBT programs have the potential to teach new students about real world scenarios that they might not otherwise have been able to learn during their standard training.

15. SUBJECT TERMS
Knowledge acquisition, peer review team, PRT, scenario-based training, SBT, safety, teams, team training, learning, human factors

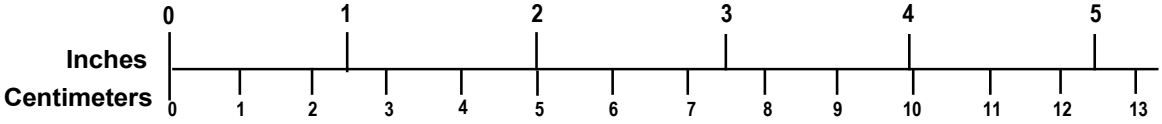
16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Jared Young
UNC	UNC	UNC		30	**19b. TELEPHONE NUMBER** *(Include area code)* (617) 494-2629

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

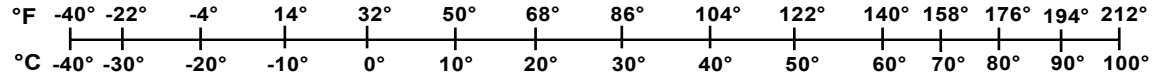
METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC	METRIC TO ENGLISH
LENGTH (APPROXIMATE)	**LENGTH (APPROXIMATE)**
1 inch (in) = 2.5 centimeters (cm)	1 millimeter (mm) = 0.04 inch (in)
1 foot (ft) = 30 centimeters (cm)	1 centimeter (cm) = 0.4 inch (in)
1 yard (yd) = 0.9 meter (m)	1 meter (m) = 3.3 feet (ft)
1 mile (mi) = 1.6 kilometers (km)	1 meter (m) = 1.1 yards (yd)
	1 kilometer (km) = 0.6 mile (mi)
AREA (APPROXIMATE)	**AREA (APPROXIMATE)**
1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)	1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)	1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)	1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)	10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (he) = 4,000 square meters (m^2)	
MASS - WEIGHT (APPROXIMATE)	**MASS - WEIGHT (APPROXIMATE)**
1 ounce (oz) = 28 grams (gm)	1 gram (gm) = 0.036 ounce (oz)
1 pound (lb) = 0.45 kilogram (kg)	1 kilogram (kg) = 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)	1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons
VOLUME (APPROXIMATE)	**VOLUME (APPROXIMATE)**
1 teaspoon (tsp) = 5 milliliters (ml)	1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp) = 15 milliliters (ml)	1 liter (l) = 2.1 pints (pt)
1 fluid ounce (fl oz) = 30 milliliters (ml)	1 liter (l) = 1.06 quarts (qt)
1 cup (c) = 0.24 liter (l)	1 liter (l) = 0.26 gallon (gal)
1 pint (pt) = 0.47 liter (l)	
1 quart (qt) = 0.96 liter (l)	
1 gallon (gal) = 3.8 liters (l)	
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)	1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)	1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)	**TEMPERATURE (EXACT)**
[(x-32)(5/9)] °F = y °C	[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSIO



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

Acknowledgements

The authors would like to thank the Federal Railroad Administration (FRA) Region 1 office for the assistance in gathering railroads to participate in a study of an experimental training program. A special thank you to Edward Flynn at FRA for his continued involvement in pushing this effort forward. Finally, thank you to the participating railroads for sharing vital data needed for the analysis of this study.

Contents

Executive Summary 1

1. Introduction 2
   - 1.1 Background 2
   - 1.2 Objectives 2
   - 1.3 Overall Approach 2
   - 1.4 Scope 2
   - 1.5 Organization of the Report 3

2. How SBT Works 4
   - 2.1 Background 4
   - 2.2 Design 5
   - 2.3 Training Objectives 5
   - 2.4 Current SBT Programs 6

3. Method 10
   - 3.1 Evaluation Purpose 10
   - 3.2 Evaluation Questions 10
   - 3.3 Constraints and Limitations 10
   - 3.4 Overview 10
   - 3.5 Training Conditions 11
   - 3.6 Participants 11
   - 3.7 Procedure 12

4. Results 14
   - 4.1 Railroad 1 14
   - 4.2 Railroad 2 15
   - 4.3 Railroad 3 16

5. Conclusion 18

6. References 19

Appendix A: Railroad 1 Conditions for Learning Questions and Responses 20

Appendix B: Railroad 2 Conditions for Learning Questions and Responses 21

Illustrations

Figure 1. Room Layout for Railroad 1 SBT Class.....6

Figure 2. Room Layout for Railroad 2 SBT Class; Left: Students and Observers Room Right: Dispatcher and Trainmaster Room.....7

Figure 3. Room Layout for Railroad 3 SBT Class; Left: Students and Observers Room Right: Dispatcher and Trainmaster Room.....8

Figure 4. Room Layout for Railroad 4 SBT Class.....9

Figure 5. Questions and Responses for COL Assessment: Railroad 1 15

Figure 6. Questions and Responses for COL Assessment: Railroad 2 16

Tables

Table 1. Training Conditions by Railroad....11
Table 2. Overview of Scenario Based Training Programs....12
Table 3. Railroad 1 Pre- and Post-Assessment Results....14
Table 4. Railroad 2 Pre- and Post-Assessment Results....16
Table 5. Railroad 3 Pre- and Post-Assessment Results....17

Executive Summary

To work safely and efficiently, railroad employees acquire knowledge and skills needed to perform their jobs through a combination of formal classroom training and on-the-job mentoring by experienced practitioners in the same craft. Through railroad participation, scenario-based training (SBT) was developed from the Federal Railroad Administration (FRA)'s Confidential Close Call Reporting System (C^3RS). In an effort to understand how SBT impacts learning, FRA reached out to the Volpe National Transportation Systems Center to evaluate the current efforts by several railroads in implementing SBT. The peer review team (PRT), comprised of labor craft employees and railroad managers, is the group responsible for reviewing event reports and recommending corrective actions. The PRT advised that creating training based on some of the scenarios documented in the reports could be one way to address unsafe conditions on the railroad.

In response to a variety of close call events, the PRT recommended developing training involving the use of role playing exercises where the crew or individual could work through the unsafe event and learn how to respond safely. In 2015, Railroad 4 in this study experimented with teaching new students how to handle scenarios when the railroad received multiple close call reports and observed challenges during operational testing and other safety related incidents. This training came to be known as SBT, which addressed a specific set of conditions that can lead to harm.

One objective of SBT was to improve the coordination of teams to operate safely through exposure to the hazardous conditions that can lead to unsafe outcomes that railroads previously identified through observations, close call reports, incident reports, and accidents. A second objective was to teach employees how to safely operate in a specific hazardous condition that can result in an unsafe outcome.

The current research evaluated the effectiveness of SBT to assess whether the training is contributing to more effective learning of safety critical behaviors. The study used a set of questions to measure knowledge before and after training. Four railroads participated in the study. To keep the identify of these railroads confidential, they will be referred to as Railroad 1, Railroad 2, Railroad 3, and Railroad 4. Railroads 1 and 2 used the SBT for refresher training for experienced employees (i.e., block training) and Railroad 3 used SBT with new student employees. Railroad 4 was unable to participate during the study period due to COVID-19.

Among the three railroads that were able to conduct training sessions, each demonstrated that SBT can lead to improvements in knowledge acquisition. New employees showed greater improvements compared to experienced employees. Knowledge acquisition improved by 17 percent for new employees and 1–3 percent for experienced employees. This improvement shows that SBT has the potential to teach new students about real world scenarios that they might not otherwise encounter during their standard training.

1. Introduction

The Federal Railroad Administration (FRA) reached out to the Volpe National Transportation Systems Center (Volpe Center) to evaluate the current efforts by several railroads in implementing scenario-based training (SBT), a form of training that several passenger railroads currently use. The research team examined how several passenger railroads incorporated SBT into their new employee training and recurrent training (i.e., annual refresher training or block training) for locomotive engineers, conductors, dispatchers, and block operators and measured the impact of this training on classroom learning.

1.1 Background

To work safely and efficiently, new railroad employees acquire the knowledge and skills needed to perform their jobs through a combination of formal classroom training and on-the-job mentoring by experienced practitioners in the same craft. For locomotive engineers, it can take 2 years before they earn their certification. For conductors, the training can range from 8 to 12 months.

SBT has proven effective in several other domains, including automobile operations. Dating back to 2003, research on automotive SBT by McKnight and McKnight concluded from a detailed analysis of crash reports that the overwhelming majority of motor vehicle crashes involving novice drivers (i.e., 16–19 years old) resulted from their failure to employ safe operating practices and to recognize or anticipate dangers (McKnight and McKnight, 2003).

A passenger railroad developed SBT in response to event reports received from FRA's Confidential Close Call Reporting System (C^3RS). In response to some event reports, a peer review team (PRT) identified training as corrective action to some of the factors contributing to these events. The training addressed many of the types of events reported to C^3RS and involved role playing so students could experience these events in a safe environment where they could make mistakes and learn from these experiences. FRA sought a wider demonstration and evaluation of this training to learn whether it would be effective in promoting learning and to share this information more broadly with industry stakeholders.

1.2 Objectives

The purpose of this evaluation was to evaluate the impact of SBT training on railroad employees in the classroom.

1.3 Overall Approach

The research team observed the training at each of the participating railroads to document how the railroads implemented SBT. Following the observations, the team created three surveys for evaluating the impact of the training on student learning. The participating railroads administered the three surveys and researchers reviewed and documented the results.

1.4 Scope

The evaluation focused on the impact of the training on classroom learning and did not evaluate the impact on application of student learning in railroad operations nor did it measure the impact on safety outcomes.

1.5 Organization of the Report

Section 2 describes SBT and how the railroads decided to explore this form of training. Section 3 details the methods for evaluating the impact of SBT classroom training and Section 4 provides the results of the evaluation. Section 5 offers conclusions on the work conducted. Appendix A contains the questions provided for Railroad 1 and Appendix B lists the questions given to Railroad 2.

2. How SBT Works

This section provides background on SBT, how it is designed, and how railroads currently implement this training.

2.1 Background

To work safely and efficiently, new railroad employees acquire the knowledge and skills needed to perform their jobs through a combination of formal classroom training and on-the-job mentoring by experienced practitioners in the same craft. This employee training focuses on learning the language of railroad operations, the operating rules, how to operate the equipment for which they are responsible, and the characteristics of the territory they will operate. The duration of this training varies by craft. For locomotive engineers, it can take up to 2 years before they earn their certification. For conductors, the training can range from 8 to 12 months. Recurrent or refresher training, which occurs on a periodic basis (e.g., annually) in a classroom environment, enables the railroads to reinforce or emphasize safety issues of concern to the railroad. Some safety topics are repeated year after year, while some safety topics vary each year depending upon the safety concerns that arose during the previous year. This training varies in duration depending upon the railroad. For both new employee training and refresher training, employees receive instruction according to their craft.

SBT has proven effective in several domains, including automobile operations. Dating back to 2003, research on automotive SBT by McKnight and McKnight concluded from a detailed analysis of crash reports that the overwhelming majority of motor vehicle crashes involving novice drivers (16–19 years old) resulted from their failure to employ safe operating practices and a failure to recognize or anticipate dangers (McKnight and McKnight, 2003). Prior to this research by McKnight and McKnight, it was assumed that novice drivers were overrepresented in vehicle crashes because they were deliberately driving in a more reckless manner. However, this study found that novice drivers were unaware that their behavior was dangerous, and they could become safer drivers with more education. Since 2006, computer-based scenario training programs have been proven effective at reducing behaviors that lead to automotive crashes. These programs include Risk Awareness and Perception Training [RAPT] (Pollatsek et al., 2006); Anticipate, Control, and Terminate [ACT] (Muttart, 2013); Secondary Task Regulatory & Anticipatory Program [STRAP] (Krishnan et al. 2015); Forward Concentration and Attention Learning [FOCAL] (Divekar et al., 2013); Less Aggressive Goals [LAG] (Zhang, Romoser & Fisher, 2014); and Accelerated Curriculum to Create Effective Learning [ACCEL] (Fisher, Young, Zhang, Knodler, Samuel, 2017). Similar training in the rail industry might also prove effective.

In the railroad domain, two FRA studies, one on stop signal overruns and another on running through misaligned switches, made clear that training and experience play a vital role in the safe and efficient operations of train handling (Multer, Safar, & Roth, 2019; Safar et al., 2019). In these studies, the authors recommended the adoption of SBT as a method for reducing the likelihood of stop signal overruns.

SBT for railroads was developed by a passenger railroad in response to event reports received from C^3RS. The PRT identified training as corrective action to some of the factors contributing to these events. The training addressed many of the types of events reported to C^3RS and involved role playing so students could experience these events in a safe environment where they

could make mistakes and learn from their experiences. After observing this training, FRA sought a wider demonstration and evaluation to learn whether this training was effective in promoting learning and share this information with industry stakeholders.

In 2015, the railroad that developed a SBT program experimented with teaching new students how to handle scenarios for which the railroad received multiple close call reports, observed challenges during operational testing, and safety related incidents. This training addressed a specific set of conditions that can lead to harm associated with railroad operations.

In 2019, FRA Region 1 held a meeting to promote the use of SBT. Several passenger railroads attended this meeting to learn about the training method and its potential benefits. Following this meeting, three railroads expressed interest and began to develop their own programs modeled after the SBT program. Each railroad adapted the training to meet its safety concerns.

2.2 Design

Training that is scenario-based focuses on a specific set of conditions that can lead to harm associated with railroad operations. The training addresses the behaviors that teams can use to prevent these conditions from causing harm or to mitigate the consequences of the harm. This can include teams that work closely together in time and space or teams that may be separated geographically or by time.

SBT uses methods like role playing, human-in-the loop simulation, and controlled field settings that enable teams to experience the conditions in which the harm may occur. Teams learn to recognize hazardous situations when they arise and to practice behaviors and communications that lead to safe outcomes or, if an unsafe event occurs, to mitigate the consequences.

SBT for new and experienced employees was designed to comply with Federal Title 49 Code of Regulations (CFR) Parts 240 and 242. The training involves participants from all crafts that would interact during the envisioned scenario. For example, if the scenario involved train operations, the exercise could include train crew members, a locomotive engineer, a conductor, an assistant conductor (brakeman), and a dispatcher. Depending upon the availability of employees from the different crafts and the design of the training scenario, railroad managers or training staff may role-play as one of the necessary craft employees.

2.3 Training Objectives

For the railroads, one objective of SBT is to improve team coordination and communication, which allows the team to operate safely through exposure to the hazardous conditions that can lead to unsafe outcomes. A second objective is to teach employees how to safely operate in a specific hazardous condition that could result in a safety incident.

The training places the student[1] in a controlled, safe environment (i.e., classroom or field) where they can experience the same type of real-world unsafe conditions that they might encounter in the field. The trainee learns how to recognize unsafe conditions, act to avoid unwanted events, and safely operate the train. Students may play one of the roles in the scenario or observe the scenario as it plays out.

[1] A student refers to either a new employee that is in the process of becoming certified to operate under Part 240 or 242 or an experienced certified employee that is receiving periodic refresher training.

2.4 Current SBT Programs

Four passenger railroads volunteered to participate in this study and are represented as Railroad 1, Railroad 2, Railroad 3, and Railroad 4. Each developed a training program adapted to their railroad and each organization implemented it in different ways. Railroad 1 conducted their first group SBT session in the fall of 2018. Railroad 2 began conducting individual craft (non-group) SBT in early 2018. Railroad 3 conducted their first training session in 2016 and Railroad 4 held their first session in November 2019. The research team studied one instance of SBT training from each railroad. The following section describes how each passenger railroad conducted that instance of student training using SBT.

2.4.1 Railroad 1

Railroad 1 offered SBT as a 1-hour module during their annual block (i.e., refresher) training course. All employees participated in this training. During this training, the SBT module consisted of two scenarios drawn from issues identified in C^3RS, operations testing, or incidents that took place during the previous year. Students participated in scenarios either around a table in the classroom (see Figure 1 for room layout), in a human in-the-loop simulator, or in the field (i.e., on actual trains or in a yard). Once the scenario was completed, feedback was provided by instructors and other students in the class.

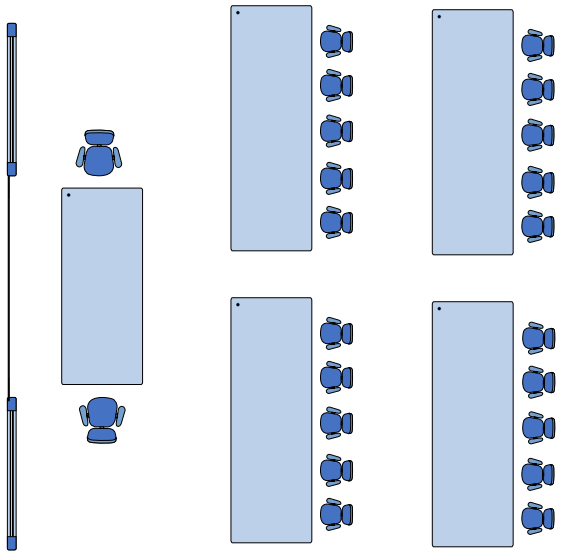


Figure 1. Room Layout for Railroad 1 SBT Class

2.4.2 Railroad 2

Training took place in a large room with chairs and desks arranged in a U-shaped layout. In the center of the U were two tables and chairs, one for a locomotive engineer and another for a conductor (Figure 2). This was the railroad's first training session with experienced employees, having previously conducted a SBT session with new employees in November 2019. Before the training session began, the instructors described SBT so the students understood the purpose of the training. Railroad 2 designed 14 scenarios for the students to experience. The students acting out each scenario sat at the two tables in the center of the U. They were given radios, paper copies of bulletin orders, rules forms, and a timetable. At the start of each scenario, the students were given an envelope that described the training situation. As the students worked through the

exercise, experienced trainmasters and dispatchers played their roles in another room, hidden from the participants. At the conclusion of each exercise, the instructors and observers discussed the scenario with the students and offered feedback on how they could improve their performance.

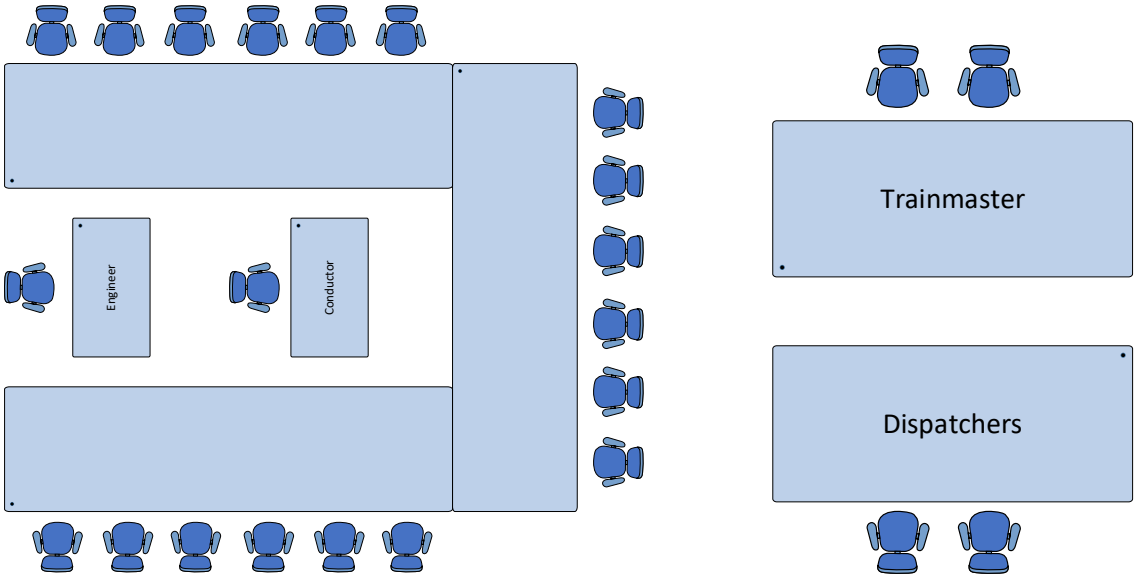


Figure 2. Room Layout for Railroad 2 SBT Class; Left: Students and Observers Room Right: Dispatcher and Trainmaster Room

2.4.3 Railroad 3

Railroad 3 offered SBT to new student engineers, conductors, dispatchers, and block operators prior to certification. Their training took place in a room with chairs and desks arranged in a U-shaped layout (Figure 3). In the center of the U were chairs for participants acting as passengers. A table for an engineer was in the front of the U-shaped layout facing a projector screen. Another table for a conductor was behind the chairs in the center of the U, with the chair for the student either facing in the opposite direction of the screen (i.e., looking away) or facing the screen, depending on the scenario. For example, the engineer's chair faced away from the screen during reverse train movements to simulate how the engineer would not be able to see out of the window while performing a reverse train movement, and then faced the screen when the train was making a forward movement. Road foremen, union representatives, and other managers sat around the table. The observers provided feedback to the students following the completion of each scenario.

The instructors introduced the training and described how it was developed. Then the instructor invited two students up to begin the first of six scenarios. The students were given a piece of paper describing the situation they would face and their role in the scenario. The two students performed a job briefing to introduce their roles to each other and then took their seats. If the scene involved video showing movement of the train, the video would begin when the engineer indicated that he was beginning operation of the train. The instructor at the front of the room controlled the video using Microsoft video playback software, and would start and stop the video at the direction of the student engineer. The conductor and engineer would communicate as needed during the scene. The students both had radios to communicate with the tower/block

operator or dispatcher located in a separate room. The training was recorded on video and students used microphones located on each table to support the video recording as well as enable the other students, trainers, union representatives, and guests to better hear them speaking.

All the feedback following the scenario came from people sitting around the table (e.g., managers, union representatives, and trainers). No feedback or comments were solicited from the students sitting in the back of the room.

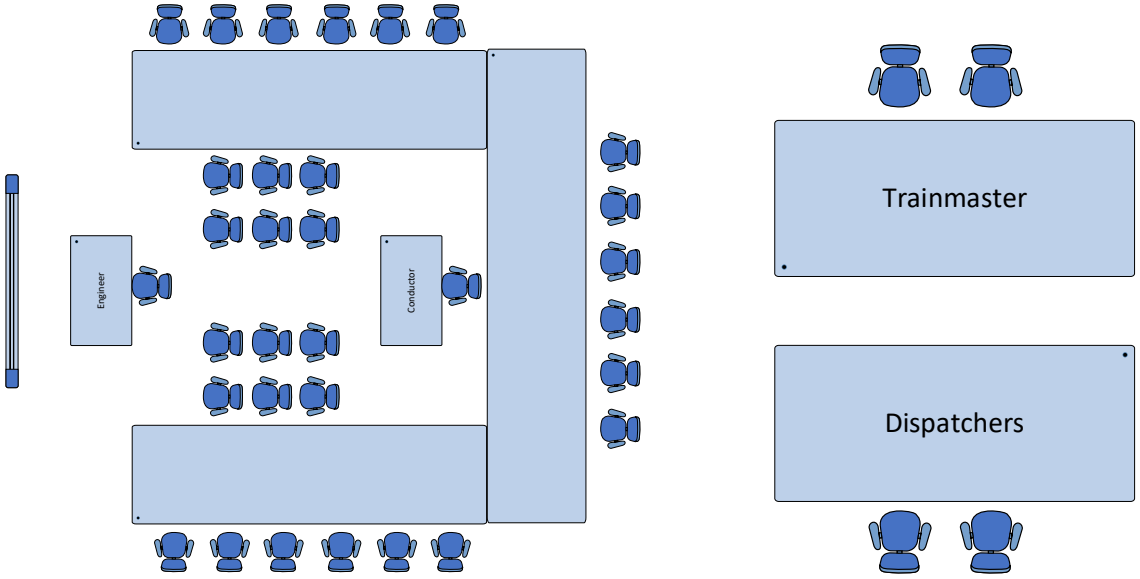


Figure 3. Room Layout for Railroad 3 SBT Class; Left: Students and Observers Room Right: Dispatcher and Trainmaster Room

2.4.4 Railroad 4

Railroad 4 offered training to new student locomotive engineers, conductors, and dispatchers toward the end of their training, prior to being certified to operate. The training took place over 3 days and consisted of 36 role playing scenarios. Students observing the exercises sat around a U-shaped conference table (Figure 4), and the students participating in the exercise sat at individual tables in the middle of the U-shaped table. Each scenario involved an engineer, a conductor, and a dispatcher.

Over the course of the 3 day training, each student participated in at least one scenario. Each scenario began with the participants receiving index cards describing the situation (e.g., performing a reverse train movement) and the role they would play. The crew worked together to achieve the goal of the scenario, with a focus on how to perform the work safely. During each exercise, one student received a "wildcard" that created an additional challenge that the team would need to address. About 95 percent of the time, teams were able to work through a scenario to its completion. In a small portion of the exercises, the teams were asked to end their scenario because they adopted incorrect procedures. At the conclusion of each scenario, the instructors went around the room and asked for feedback from students and observers. Instructors for each of the three crafts also provided feedback to the students. Following this feedback, the instructors reviewed the real-world event and explained in detail what occurred. They also gave feedback to the students on how to handle the scenarios successfully.

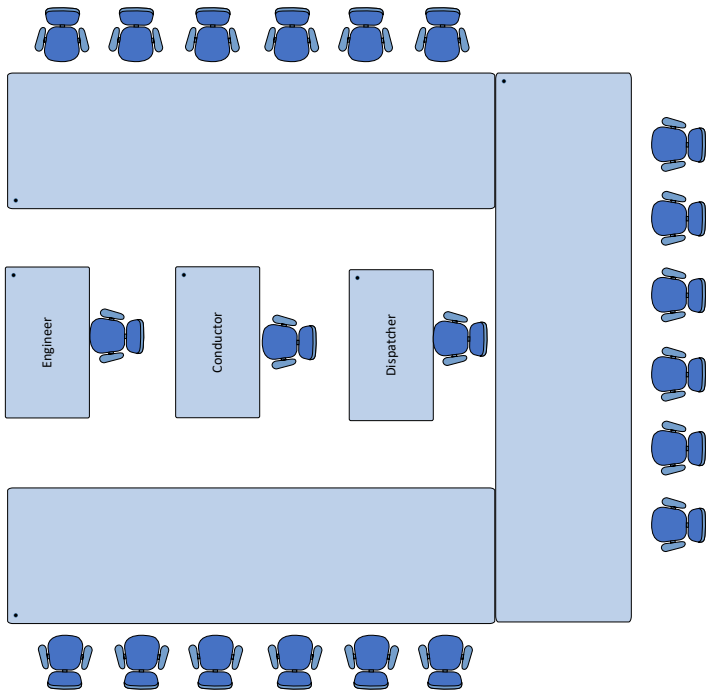


Figure 4. Room Layout for Railroad 4 SBT Class

3. Method

This section describes the method researchers used for evaluating the impact of SBT on employee learning. The team collected data over a period of 12 months, from September 2021 to August 2022.

3.1 Evaluation Purpose

Researchers evaluated the effectiveness of SBT to learn if the training contributed to more effective learning of safety critical behaviors. Specifically, the team evaluated how students responded to the training and whether students demonstrated learning. Researchers posed three questions regarding the effectiveness of the training, as discussed below.

3.2 Evaluation Questions

The questions used in the training evaluation were:

1. Do individuals demonstrate knowledge of what actions to take in response to the scenarios?
2. How does training effectiveness vary with use of role playing alone compared to role playing using video or computer-based simulation or OJT in the field?
3. To what extent does the training focus on individual knowledge and skills vs. team-based knowledge and skills?

3.3 Constraints and Limitations

The training evaluation was intended to help the railroads and FRA learn whether SBT achieves improvements in learning behaviors and strategies for safe job performance. Researchers also sought to identify strengths and weaknesses in the different ways the training was implemented.

For this research, the team depended upon the railroads engaged in SBT to collect the data needed for evaluation. This includes data collection prior to, during, and after training. In several cases, the railroads were unable to obtain evaluation data due to time limitations during the training.

Due to the impacts of COVID-19, the participating railroads focused their attention on critical aspects of operation and in-person training was minimized to include only that deemed necessary. For this reason, Railroad 4 was not able to conduct any training during the research period and therefore was not able to submit training data for evaluation. Also, while railroads were focused on current operations, requests for information from researchers was sometimes delayed. These delays contributed to a delay in completing this study.

3.4 Overview

The following method was used to evaluate this training:

1. Compare knowledge retained by pre-training and post-training instruments.
    a. The study identified the following learning objectives:

i. What knowledge should students demonstrate? How much is scenario-specific?

ii. What skills and knowledge should be generalized (e.g., communications skills)?

b. The study assessed whether learning took place.

i. How well did students learn the information defined by the learning objectives?

ii. How did learning vary with the methods used (e.g., classroom, video, computer-based simulation)?

2. Administer an engagement questionnaire to measure how the students reacted to the conditions for learning.

a. Did the students who participated in the training find it helpful?

b. Did the students believe that they understood the goals of the training?

c. Did the students feel engaged in the conversation?

3.5 Training Conditions

Table 1 shows the conditions under which training was conducted and the student crafts that participated in the training. The conditions reflect differences in the number of scenarios that the railroads presented during training and the media used.

Table 1. Training Conditions by Railroad

Railroad	1	2	3	4
Duration	1 Hour	2–3 Hours	1 Day	3 Days
Media Used	Tabletop Role Play uses paper and radios	Role Playing with Video of moving train uses paper, radios, and computer-based video	Field, Human in the Loop Simulators, or Tabletop Role Play uses paper, radio, computer based simulation, and equipment in the field	Tabletop Role Play uses paper and radios
Crafts Involved	Engineer, Conductor, Dispatcher	Engineer, Conductor, Dispatcher, Foreman	All Crafts	Engineer, Conductor, Dispatcher

3.6 Participants

Four passenger railroads volunteered to participate in this study. To provide confidentiality, they are referred to as Railroad 1, Railroad 2, Railroad 3, and Railroad 4.

The SBT training for each of the participating railroads varied in duration; Table 1 shows the number of scenarios in which the students participated. The training duration for the participating railroads was between 1–3 days depending upon the number of scenarios designed by each railroad.

The craft of the students that participated in SBT also differed between railroads. Table 2 shows the number of employees participating by craft and railroad. Only Railroad 3 included new employees learning their craft; the participants from Railroads 1 and 2 were experienced

employees. This research focused on the self-assessments of locomotive engineers, conductors, and dispatchers and/or block operators. Participation by individual students occurred in one of two ways, either participating in or observing the scenarios. Railroad instructors selected the students to participate in each scenario. While most scenarios involved a locomotive engineer and conductor, some also included student dispatchers and block operators. The number of students and scenarios determined the number of scenarios in which students participated. Since only two students generally participated in each scenario, students observed more scenarios than they participated in. Instructors and non-student employees also participated in the scenarios by playing the other roles required in some of the scenarios.

Table 2. Overview of Scenario Based Training Programs

Railroad	1	2	3
Number of students	Conductor – 76 Assistant Conductor – 18 Locomotive Engineer – 37 Total – 131	Conductor – 15 Locomotive Engineer – 5 Total – 20	Conductor – 7 Locomotive Engineer – 6 Block Operator – 1 Total – 14
Training Type	Block Training	Block Training	New Student Training
Duration	1 hour	2 hours	3 days

3.7 Procedure

Researchers administered three surveys to evaluate the impact of training on learning.

1. Pre-training, instructor-administered assessment of knowledge and skill acquisition
2. Post-training, instructor-administered assessment of knowledge and skill acquisition
3. Assessment of conditions for learning (COL)

3.7.1 Pre- and Post-Training Instructor-Administered Assessment

The research team developed a paper-based assessment. Each railroad's training instructors administered the assessment before SBT began and at the conclusion of the training. The assessment measured each student's knowledge in responding to the situations encountered in the training scenarios.

The research team worked with the training instructors at each of the participating railroads to develop the questions for each assessment. The content for the questions came from the learning objectives developed by the railroads before the training began and consisted of multiple-choice questions. The post-assessment version of the instructor-administered survey distinguished responses from students that participated in the scenario from students that observed the training. This design enabled discrimination in learning impact between observations of the scenario compared to participation in the scenario.

3.7.2 Questionnaire Development to Assess the Conditions for Learning

After employees completed the training, instructors administered a third and final questionnaire to assess how the conditions present during the training (e.g., media used, engagement with instructors, engagement with other students, etc.) contributed to learning and what conditions might have impaired learning.

3.7.3 Survey Administration

Researchers provided the three SBT surveys to the training staff and instructed them on how to administer the surveys in the classes. The pre-assessment survey was administered by the training instructors prior to the training taking place. Following the training, the instructors administered the post-assessment survey and the COL questionnaire. These forms were collected immediately after completion and given to the research team to analyze.

3.7.4 Data Collection and Analysis

The research team measured the change in learning between the assessments and scored the questionnaires for each railroad. Aggregate scores were summarized across the participating railroads.

4. Results

The research team collected data from the surveys discussed in Section 3.7 (i.e., the pre- and post-training assessments and the COL questionnaire) from three of the participating railroads (i.e., Railroads 1, 2, and 3) over a 12 month period. Railroad 4 was unable to perform any training classes during this time due to restrictions from the COVID-19 pandemic.

Each railroad administered the surveys in the same fashion. The pre-training assessment was given before the training occurred and the post training assessment and the COL questionnaire were completed after the training. As shown in Table 2, each railroad conducted their training in a slightly different way, so the team performed analysis individually for each railroad to determine if there was a statistical significance between the pre- and post-training assessment. In addition, researchers compiled summary statistics from the COL questionnaire to gain a better understanding of how effective the students believed this type of training might be for them.

4.1 Railroad 1

Railroad 1 conducted 11 classes, with an average class size of 11 students. SBT was offered to experienced employees during their yearly refresher training. The breakdown of craft is listed in Table 3.

4.1.1 Pre- and Post-Training Assessment

Overall, students responses showed a 1.4 percent in learning from pre-test to post-test. To determine if this change was statistically significant, the researchers performed a two-sample proportion test. The change in performance was not statistically significant.

While the results were positive (i.e., the post-evaluation results were better than the pre-evaluation results), the change was small. The researchers also looked at how craft may affect the improvement from the pre-evaluation and post-evaluation questioners by using a Tukey HSD multiple comparisons of means test. This test displayed a p-value of 0.535 which once again was not statistically significant. However, results for each craft were positive and a small improvement was shown for each craft (Table 4).

Table 3. Railroad 1 Pre- and Post-Assessment Results

Craft	Number of Students	Pre-Test Score (%)	Post Test Score (%)	Percent Change
Conductor	76	80	81	1
Assistant Conductor	18	81	82	1
Locomotive Engineer	37	74	77	3
Overall	131	78	79	1

4.1.2 COL Assessment

Railroad 1 collected the COL questionnaire responses following the post-training assessment. The COL for Railroad 1 consisted of 14 questions. Out of the 131 students whose responses were analyzed, each student participated in an average of 1.6 scenarios and observed an average of

1.96 scenarios. Questions 8 through 13 were rated on a scale from 1 to 4. The average response was 3.85, indicating that overall students felt this training was very useful. The lowest rating was given for question 17, which asked students how challenging they felt the training was; on average the students rated the course difficulty at 1.9 out of 4, meaning it was not very challenging for the students. A select list of questions and responses can be found in Figure 5, and the complete list of questions and responses can be found in Appendix A.

Figure 5. Questions and Responses for COL Assessment: Railroad 1

4.2 Railroad 2

The team evaluated one class conducted by Railroad 2 over the research period. Approximately 2 hours of SBT was given to experienced employees during their yearly refresher training. The breakdown of craft is listed in Table 4. Researchers analyzed the responses from 20 students and found an improvement of 3 percent in evaluation performance scores.

4.2.1 Pre- and Post-Training Assessment

To determine if this change was statistically significant, the researchers performed a two-sample proportion test. This test produced a p-value of 0.3632. Using an $a = .05$, the team concluded that because the p-value is greater than a, the difference between the proportion for the pre-evaluation questionnaire is no different than the proportion for the post-evaluation questionnaire. This means that there is no significant difference between pre-scenario evaluations and post-scenario evaluations. While the results were positive (i.e., the post-evaluation results were better than the pre-evaluation results), the difference was not great enough to show a statistical significance given the relatively small sample size.

The researchers also looked at how craft may affect improvement from the pre-evaluation and post-evaluation surveys. Researchers then used a Tukey HSD multiple comparisons of means test. This test displayed a p-value of 0.0056. Since the p-value was less than $a = .05$, researchers concluded that there is a significant difference between how the crafts preformed on the assessments, with greater improvements shown from the conductors.

Table 4. Railroad 2 Pre- and Post-Assessment Results

Craft	Number of Student	Pre-Test Score (%)	Post Test Score (%)	Percent Change
Conductor	15	67	70	3
Locomotive Engineer	5	88	90	2
Overall	20	72	75	3

4.2.2 COL Assessment

The COL for Railroad 2 consisted of 15 questions. Out of the 20 students whose responses were analyzed, each student participated in an average of 3 scenarios and observed an average of 4.85 scenarios. Questions 7 through 12 were rated on a scale from 1 to 4. The average response was 3.81, indicating that overall students felt this training was very useful. Once again, the lowest rating was given for question 16, which asked students how challenging they felt the training was. On average the students rated the course 3.2 out of 5 on difficulty, meaning it was not very challenging for the students. A select list of questions and responses can be found in Figure 6 and the complete list of questions and responses can be found in Appendix B.

Figure 6. Questions and Responses for COL Assessment: Railroad 2

4.3 Railroad 3

Researchers evaluated on class conducted by Railroad 3 during the research period. SBT was given to new student trainees at the end of their formal training and lasted 1 day. Table 5 lists the breakdown of craft. The team analyzed the responses from 14 students and observed an improvement of 16.67 percent in performance from pre- to post-evaluation.

4.3.1 Pre- and Post-Training Assessment

To determine if this change was statistically significant, researchers performed a Chi-squared test. The results were statistically significant ($\chi^2 = 8.7231$, df = 1, p = 0.003). Using an $a = .05$, researchers concluded that because the p-value was less than a, the hypothesis test shows that SBT demonstrated a statistically significant improvement in knowledge acquisition from the pre-training assessment to the post-training assessment.

The researchers also looked at how craft may affect the improvement from the pre-evaluation and post-evaluation questioners. The team used a Tukey HSD multiple comparisons of means test to compare the improvements between the different crafts (F-value = 7.777, df = 2, p = 0.0009). Since the p-value was less than a = .05, the team concluded that there is a significant difference by craft. While the conductors showed greater improvements than the locomotive engineers, the differences were not statistically significant, possibly due to the small sample size in each of these groups. All the crafts showed improvement from pre-assessment to post-assessment except for the block operator craft. The block operators scored 100 percent on both the pre- and post-assessment, therefore there was no opportunity to demonstrate an improvement in learning.

Table 5. Railroad 3 Pre- and Post-Assessment Results

Craft	Number of Student	Pre-Test Score (%)	Post Test Score (%)	Percent Change
Conductor	7	80	100	25
Locomotive Engineer	6	90	100	11
Block Operator	1	100	100	0
Overall	14	86	100	17

4.3.2 COL Assessment

Due to time constraints, Railroad 3 only asked three questions on their COL assessment. Out of the 14 students whose responses were analyzed, each student participated in an average of 1 scenario and observed an average of 6.2 scenarios. Students rated the quality of the media used in training moderately high with an average rating of 3.8 out of 5. This indicates that the students found the media somewhat helpful.

5. Conclusion

In this study, researchers found that SBT demonstrated greater improvements in learning for new student employees than for experienced employees. New student employees improved approximately 17 percent from pre-assessment to post-assessment. This improvement suggests that SBT has the potential to teach new students about real world scenarios that they might not otherwise encounter during their standard training. Replicating this research with more railroads, including freight service, and larger samples will inform whether these results generalize across the railroad industry.

For the two railroads that used SBT for refresher training, learning improved from the pre-assessment to the post-assessment by 1–3 percent. More research is needed to understand why the performance improvements for experienced employees were smaller than those for new employees and how to improve performance for this group.

The three railroads that returned results tailored the SBT, the media used in training, and the three surveys to fit their timeframe and priorities. Railroad 1 used radios and paper to support a role playing activity while Railroad 2 included radios, paper, and video to support role playing. Railroad 3 used radios, paper, and computer-based simulation to support role playing activity. These differences make it difficult to compare results between railroads, although there were some similarities in the questions on the COL assessments.

Responses comparing these COLs suggest that both new employees and experienced employees found the training useful. While the results of this study are promising, more research is needed to understand how to further improve on these findings, especially with experienced employees. For new students, replicating this research with larger sample sizes and variations in how railroads apply SBT is needed to better understand the effects of this training on learning.

Two key aspects of this training were not evaluated by this study but deserve consideration. This training focused on events that each of the railroads experienced as either close calls or incidents. The training provided a mechanism to learn how to address these risks in a safe environment. Learning whether this training reduces the potential for these events to recur would be valuable but difficult to measure. A second aspect of the training addressed team interactions and focused on how employees can improve communication and collaboration with their teams. Like crew resource management and non-technical skills training, SBT can provide the soft skills needed for successful team performance within the railroad industry. Learning how this training affects team interactions in the field can inform railroad training methods for new and experienced employees.

6. References

Cook, D. A., Thompson, W. G., Thomas, K. G., Thomas, M. R., & Pankratz, V. S. (2006). Impact of Self-Assessment Questions and Learning styles in Web-Based Learning: A randomized, Controlled Crossover Trial. *IT in Medical Education*, 231–238.

Divekar, G., Pradhan, A. K., Masserang, K. M., Reagan, I., & Fisher, D. L. (2013). A simulator evaluation of the effects of attention maintenance training on glance distribution of younger novice drivers inside and outside the vehicle. *Transportation Research Part F: Traffic Psychology and Behaviour, 20*, 154–169.

Fisher, D. L., Young, J., Zhang, L., Knodler, M., & Samuel, S. (2017). *Accelerating Teen Driver Learning: Anywhere, Anytime Training*. Washington, DC: AAA Foundation for Traffic Safety.

Krishnan, A., Samuel, A., Dundar, C., Romoser, M. R., & Fisher, D. L. (2015). Evaluation of a Hazard Anticipation Training Program (STRAP) on Secondary Task. *Transportation Research Board 94th Annual Meeting* (pp. 1–18). Washington, DC: Transportation Research Board.

McKnight, J. A., & Mcknight, S. A. (2003). Young novice drivers: careless or clueless? *Accident Analysis and Prevention*, 921–925.

Multer, J., Safar , H., & Roth , E. (2019). *Why do Passenger Trains Pass Stop Signals? A Systems View*. Technical Report No. DOT/FRA/ORD-19/19, Washington, DC: Federal Railroad Administration.

Muttart, J. W. (2013). *Identifying hazard mitigation behaviors that lead to differences in the crash risk between experienced and novice drivers*. Doctoral Dissertations Available from Proquest. AAI3589108.

Perera, J., Perera, J., Abdullah, J., & Lee, N. (2009). Training simluated patients: evaluation of a training approach using self-assessment and peer/tutor feedback to improve performance. *BMC Medical Education, 9*.

Pollatsek, A., Reichle, E. D., & Rayner, K. (2006). Tests of the E-Z Reader model: exploring the interface between cognition and eye-movement control. *Cognitive Psychology, 52*(1), 1–56.

Safar, H., Roth, E., Multer, J., & France, M. (2019). *Why Do Passenger Trains Run through Switches in the Rail Yard?* Technical Report No. DOT/FRA/ORD-19/37, Washington, DC: Federal Railroad Administraion.

Tronsmoen, T. (2008). Associations between self-assessment of driving ability, driver training and crash involvement amoung young drivers. *Transportation Research Part F*, 334–346.

Wänglund, A. (2011). Assessing Subjective Driving Skills: An Example of Development and Validation of a Self-Assessment Instrument. In D. Hennessy, *Traffic Psychology: An International Perspective* (pp. 285–296). Nova Science Publishers, Inc.

Appendix A: Railroad 1 Conditions for Learning Questions and Responses

This appendix shows the list of questions for Railroad 1's Conditions for Learning Assessment. Questions were given with different scales. The below figures (Figure A1, Figure A2, and Figure A3) show the average response for each question as well as the minimum and maximum score each question could be rated by the students (0–3, 0–4, and 0–5). The figures differ by the maximum score.

Figure A1. Questions and Responses for Conditions for Learning Assessment: Railroad 1 (Scale 0 to 3)

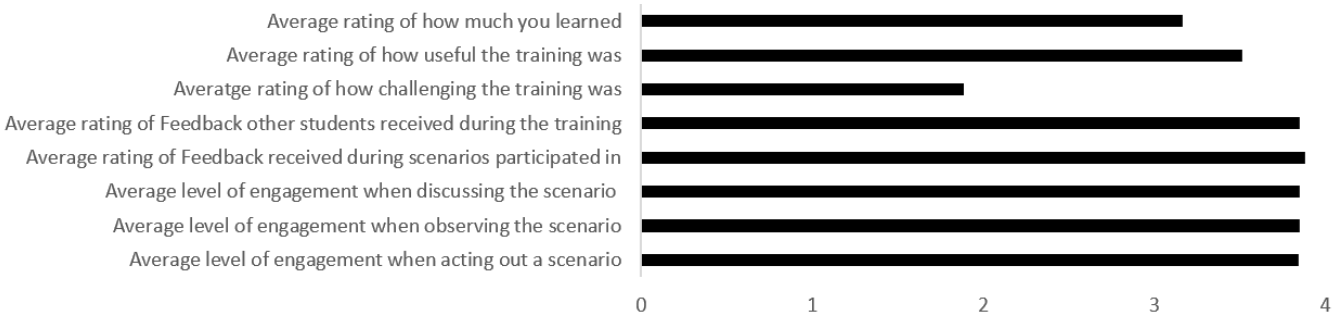


Figure A2. Questions and Responses for Conditions for Learning Assessment: Railroad 1 (Scale 0 to 4)

Figure A3. Questions and Responses for Conditions for Learning Assessment: Railroad 1 (Scale 0 to 5)

Appendix B: Railroad 2 Conditions for Learning Questions and Responses

This appendix shows the list of questions for Railroad 2's Conditions for Learning Assessment. The below figures (Figure B1, Figure B2, and Figure B3) show the average response for each question as well as the minimum and maximum score each question could be rated by the students (0–3, 0–4, and 0–5). The figures differ by the maximum score.

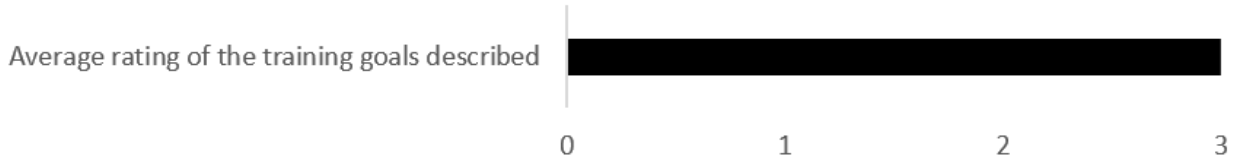


Figure B1. Questions and Responses for Conditions for Learning Assessment: Railroad 2 (Scale 0 to 3)

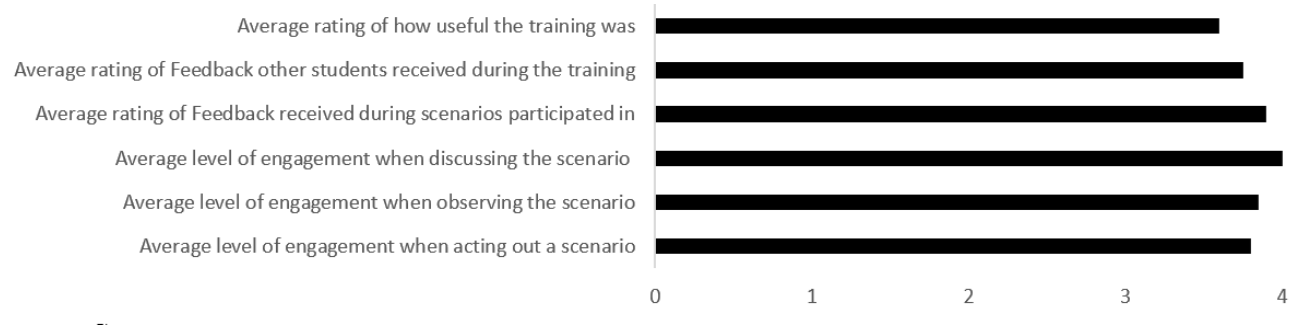


Figure B2. Questions and Responses for Conditions for Learning Assessment: Railroad 2 (Scale 0 to 4)

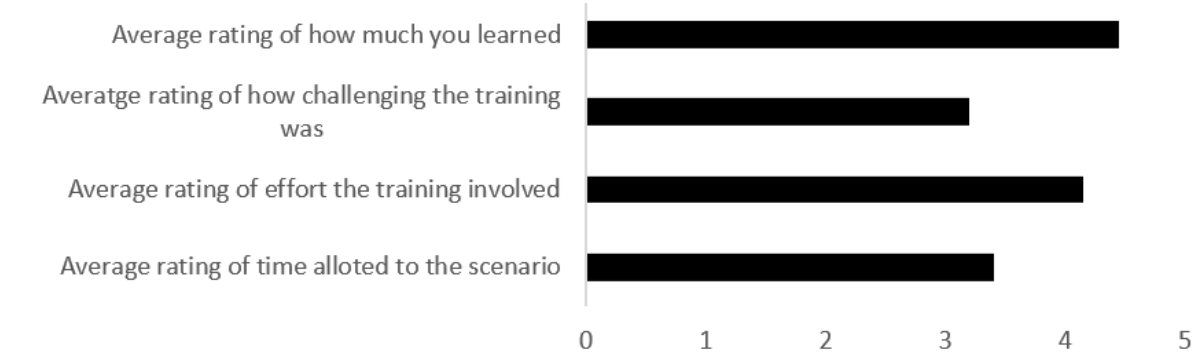


Figure B3. Questions and Responses for Conditions for Learning Assessment: Railroad 2 (Scale 0 to 5)

Abbreviations and Acronyms

ACRONYMS	DEFINITION
ACCEL	Accelerated Curriculum to Create Effective Learning
ACT	Anticipate, Control, and Terminate
CFR	Code of Federal Regulations
COL	Conditions for Learning
C^3RS	Confidential Close Call Reporting System
FRA	Federal Railroad Administration
FOCAL	Forward Concentration and Attention Learning
LAG	Less Aggressive Goals
NJT	New Jersey Transit
PRT	Peer Review Team
RAPT	Risk Awareness and Perception Training
SBT	Scenario-Based Training
STRAP	Secondary Task Regulatory & Anticipatory Program
Volpe Center	Volpe Transportation Systems Center