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Expanding Summer Youth Programs in Rail through Virtual Learning and a National Campus Network – Phase I Report

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14. ABSTRACT

FRA supported Michigan Technological University (Michigan Tech), in collaboration with Pennsylvania State University Altoona (Penn State Altoona) and the University of Illinois, Urbana-Champaign (UIUC), to establish a Tracks to the Future: Railroad Transportation and Engineering summer program for high school students. Phase 1 of this program was offered in two formats: 1) a traditional, week-long, on-campus program (at Michigan Tech only) and 2) a hybrid version of the program at Michigan Tech, Penn State Altoona, and UIUC. FRA funded the course development, program fees for the students (including meals and housing), and field visit expenses at the host site. Rail industry companies provided limited travel support for students in need to reach the host site.

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1 cup (c)	=	0.24 liter (l)	1 liter (l)	=	0.26 gallon (gal)
1 pint (pt)	=	0.47 liter (l)			
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1 gallon (gal)	=	3.8 liters (l)			
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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)
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Inches	0			1		2			3		4			5	
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°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

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    - Lake Superior and Ishpeming Railroad
    - Mineral Range Railroad
    - Eagle Mine (Lundin)
    - Pettibone
    - Railroaders Memorial Museum (Altoona, PA)
    - Norfolk Southern Railway
    - Allegheny Portage Railroad Museum
    - Monticello Railway Museum

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Executive Summary

The rail industry has long acknowledged the problem of personnel approaching retirement age and a lack of new hires to replace the aging workforce. The Federal Railroad Administration (FRA) 2011 Railroad Industry Modal Profile (FRA, 2011) and the 2016 update to the report (FRA, 2016) discuss these challenges. Since students who choose to participate in higher education often arrive at universities and colleges with a predefined career in mind, it is critical that the industry develop a pre-college program with a nationwide focus that can introduce students to the modern side of the rail industry.

FRA supported Michigan Technological University (Michigan Tech), in collaboration with Pennsylvania State University Altoona (Penn State Altoona) and the University of Illinois, Urbana-Champaign (UIUC), to establish a *Tracks to the Future: Railroad Transportation and Engineering* summer program for high school students. Phase 1 of this program was offered in two formats: 1) a traditional, week-long, on-campus program (at Michigan Tech only) and 2) a hybrid version of the program at Michigan Tech, Penn State Altoona, and UIUC. FRA funded the course development, program fees for the students (including meals and housing), and field visit expenses at the host site. Rail industry companies provided limited travel support for students in need to reach the host site.

The program received wide interest across the nation. A total of 66 students from 17 different states participated in the program, the majority of whom were rising 11 or 12 grade students. Almost one third of participants represented minorities, although only three female students participated.

The course content was nearly identical between the traditional and hybrid programs, but the delivery method was different. For the traditional program students, all activities took place at the Michigan Tech campus over five days. Students in the hybrid program first spent two days participating in live remote sessions via Zoom and completing hands-on activities at home, then traveled to one of the host campuses midweek for two days of on-campus activities and field visits.

Overall, both formats of the program were successful. Feedback from students and their parents was very positive for both the traditional and hybrid programs. The team also saw improvement in railroad knowledge among students in both formats when comparing self-assessments before and after the program. Researchers found that improvements could be made in program coordination, the registration process, and instruction, especially in the hybrid program.

1. Introduction

The Federal Railroad Administration sponsored Michigan Technological University (Michigan Tech), in collaboration with Pennsylvania State University at Altoona (Penn State Altoona) and the University of Illinois, Urbana-Champaign (UIUC) to establish a *Tracks to the Future, Railroad Transportation and Engineering* summer program for high school students based on Michigan Tech's successful, decade-long program. In the summer of 2022, the team conducted a weeklong program in two different formats: 1) a full week, on-campus experience offered only at Michigan Tech and 2) a hybrid program, where students participated in two days of remote, synchronous education, one travel day to one of three host universities, and two days on-site at the selected campus. FRA provided funding for the course development, program fees for the students (including meals and housing), and field visit expenses at the host site. Rail industry companies provided limited travel support for students in need to reach the host site.

1.1 Background

The rail industry has long acknowledged the challenge of replacing personnel approaching retirement age with new hires, many from college rail programs. Since students often arrive at universities and colleges with a predefined career in mind, it is critical for the rail industry to develop a pre-college program with a nationwide focus that can introduce students to the modern side of the industry, including critical safety aspects and the many high-tech applications and jobs available. The rail industry should develop a program that can engage students before they determine their college careers, and use that program to stimulate student interest in the rail industry.

Most pre-college experiences in railroading are focused on rail history and are sponsored by railroad museums or scenic railroads. There may be nationwide interest in rail transportation among students, but it is challenging to attract large groups of participants that share a specific geographic location. A nationwide university network that supports a hybrid program with combined virtual learning on rail transportation and site-specific campus visit for activities and field trips would be the most efficient approach to expand the reach of these pre-college rail industry programs.

1.2 Objectives

The objectives of this project included transforming and modifying a successful on-campus program at Michigan Tech by incorporating expertise and activities from the other primary universities in the project (Penn State Altoona and UIUC). In Phase 1, the team concentrated on reimagining the curriculum and implementing it in both on-campus and hybrid (i.e., online combined with on-campus) formats. Offering the course in two formats allowed researchers to compare the outcomes of each cohort.

1.3 Overall Approach

The team developed a unified curriculum that introduced students to a variety of topics related to rail transportation and engineering. Researchers used the Canvas learning management system and Zoom webinars as the main methods of delivery for the synchronous online portion of the program. A variety of instructional methods were used, including videos, team assignments, Kahoot![1] competitions to keep the online program interesting, and a materials package mailed to all hybrid students for tabletop activities. The team also developed several hands-on activities and competitions for the on-campus portion of the program, including field visits to rail industry facilities. The approach is scalable and minimizes the workload for participating universities, making it ideal for subsequent, expanded phases of the program.

1.4 Scope

In Phase 1, the research team planned the program's structure, developing marketing materials to encourage enrollment, creating instructional materials and activities, and conducting the programs (on-campus and hybrid), including pre-, and post-assessments for learning and belongingness.

1.5 Organization of the Report

This report summarizes the preparations, implementation and lessons learned from the first year of the Tracks to the Future program. The marketing efforts to attract students to the program are discussed in Section 2. Section 3 presents the demographic information of the student participants, and Section 4 outlines the program's curriculum and educational methods. Section 5 presents a skills assessment and discusses issues and lessons learned encountered in the first year of implementation. Finally, in Section 6 the team discusses conclusions from the research and outlines recommended changes for the second phase of the project.

[1] Kahoot! is an online educational gaming system with instructor prepared questions. Students compete to answer questions quickly and correctly. https://kahoot.com/schools-u/

2. Program Preparations, Marketing and Registrations

The following sections provide a summary and timeline of marketing efforts, as well as discussion on registration coordination between the host universities.

2.1 Marketing Activities and Deadlines

The team began marketing activities by brainstorming for a new name for the program. The goal was to select a name that concentrates on what the future of railroads will be rather than what they have been in the past. Researchers also wanted to make sure the word “engineering” was included in the title, as some of the university programs involved concentrate solely on engineering aspects. The team chose the name *Tracks to the Future: Rail Transportation and Engineering*.

Once the title and framework for the program was established, the team started systematic marketing efforts. Table 1 provides a list of marketing activities and deadlines included in the program preparations. The marketing was done through multiple media, including a website (Michigan State, n.d.), the summer youth program units within each host university, and specific targeted rail industry and stakeholder marketing through each rail transportation program. Marketing efforts were synchronized with other summer youth programs at the host universities as much as possible.

Table 1. Marketing Activities

Item	Dates and Notes
Branding for program. *Tracks to the Future: Railroad Transportation and Engineering* website (Michigan State, n.d.)	Early November, 2021
Michigan Tech Summer Youth Programs website	Initial materials on web late 2021. Registration open early January 2022
Marketing Flyer completed	January 23, 2022
RailPrime article published by Progressive Railroading – *Tracks to the Future: Three universities join forces to attract future railroaders (Sneider, 2022)*	January 26, 2022
Rail industry magazine calendars	Early February 2022
AREMA Members Forum and Committee 24 Forum (see flyers in Figure 2 and Figure 3)	February 24, 2022
UIUC marketing (with flyers)	Email to contact list Feb 24, 2022 – 19,000 recipients
Email to list of railroad museums and tourist railroads (with flyers)	February 25, 2022 – approximately 300 locations
Email to Michigan Tech RTP contact lists (with flyers)	February 25, 2022, follow up early April 2022 – about 1,500 recipients
UIUC and Penn State Altoona marketing (email with flyers)	Late February, over 20,000 students
NRC monthly bulletin (NRC, 2022)	March 31, 2022

Marketing emails, including program flyers (Figure 1 and Figure 2), were sent to approximately 25,000 email addresses on a list compiled by three participating rail programs and to more than 30,000 prospective students through the Michigan Tech summer youth program email list. Progressive Railroading also wrote an article on the program and published it to their RailPrime customers (see item in Table 1).

Figure 1. Tracks to the Future Traditional (On-Campus) Program Flyer

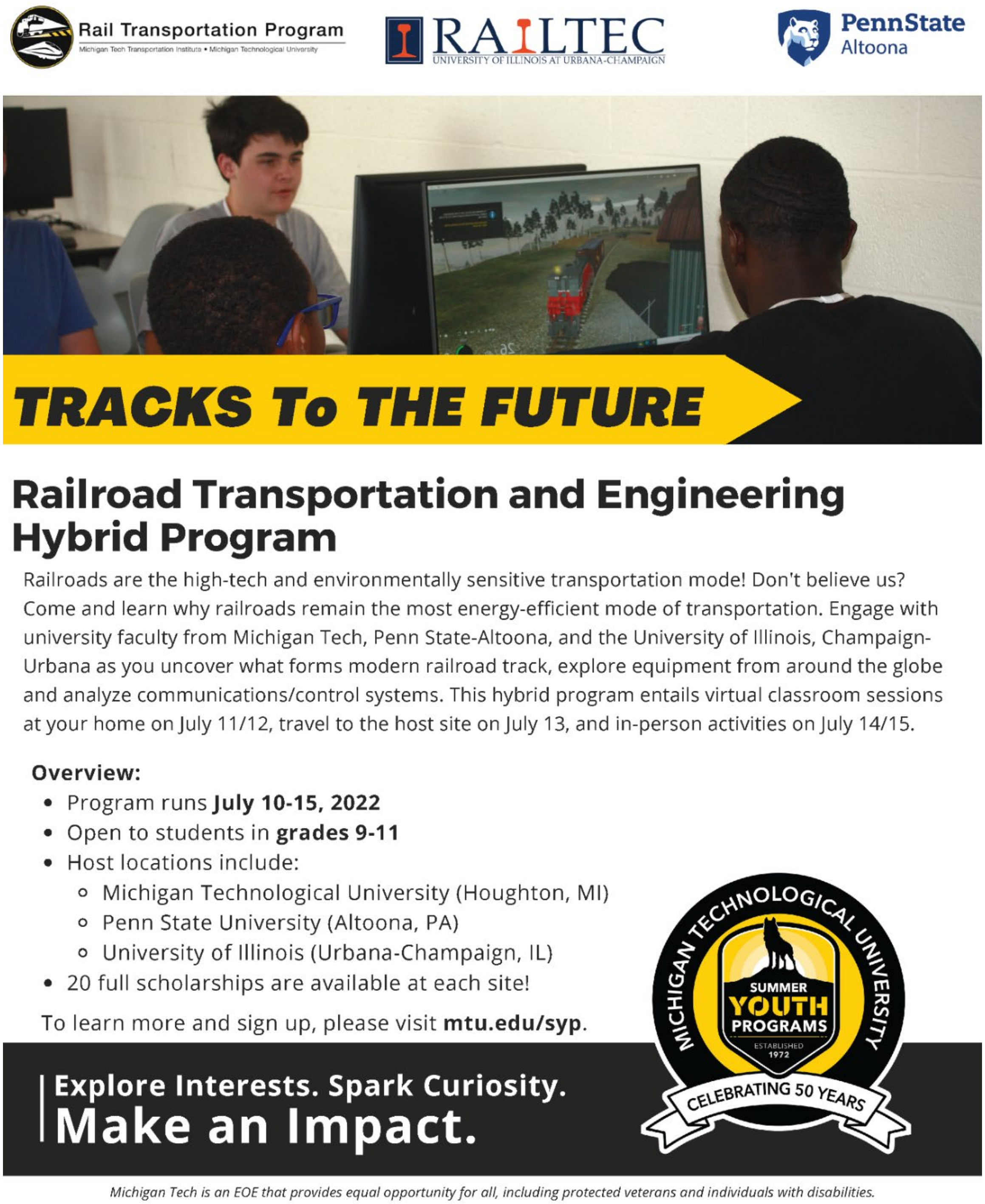

Figure 2. Tracks to the Future Hybrid Program Flyer

2.2 Registration Process

Since two structurally different programs were offered (i.e., a traditional on-campus version at Michigan Tech and the hybrid version at all three participating campuses), the registration process was customized for each program. The registration for Michigan Tech's on-campus program was handled through the Summer Youth Program (SYP) website for consistency with other programs offered by Michigan Tech's SYP. A link to the Tracks to the Future program was placed under the Scholarship Programs section of the website linking to a short description of the program and its requirements. Other links led to supplemental forms (a transcript, a letter of recommendation from a teacher, and a short essay) required for this program, which could be attached to the application or emailed separately to SYP staff.

Registration for the hybrid program was conducted using a two-step process. First students used a Google Form (Appendix A) to register through Michigan Tech and select the preferred host site for the on-campus portion. Once assigned to a university location, final registration was handled by staff at that assigned location**.** This generally included confirming the student would participate, collecting arrival and departure information, and gathering any additional information required to allow students to access the selected university's lodging and meals**.** Michigan Tech's hybrid registration was very similar to the process for the traditional program.

3. Student Participation and Demographics

3.1 Summary of Participants

Ninety students completed an initial application for the 2022 Tracks to the Future program, 66 in the hybrid program and 24 in the traditional on-campus program at Michigan Tech. Some hybrid program locations were oversubscribed so some students were offered their second choice of location, and some families found that the program timing or travel requirements required them to decline their program slot after registration. The final participant count was 22 students in the Michigan Tech traditional program and 44 in the combined hybrid cohorts.

Table 2 provides a breakdown of students who completed the summer program between each cohort, based on their grade level, gender, and minority status. Most participants were starting their junior or senior year of high school in the fall. A substantial portion of the participant pool was comprised of minority students in the cohorts (35 percent) but the team had difficulties recruiting female students (<5 percent).

Table 2. Tracks to the Future Student Demographics

	Michigan Tech Traditional	Michigan Tech Hybrid	Penn State Hybrid	UIUC Hybrid	TOTAL
Total Students	22	7	21	16	**66**
12th Grade	7	2	9	6	**24**
11th Grade	12	1	9	9	**31**
10th Grade	3	0	3	1	**7**
9th Grade	0	3	0	0	**3**
Male	22	7	21	12	**62**
Female	0	0	0	3	**3**
Minority	8	2	8	5	**23**

3.1.1 *Michigan Tech Traditional*

Michigan Tech's traditional, five-day, on-campus session ran from June 27-July 1. Initially, 24 students were offered slots in this offering, but one student stopped communicating with the program staff in early June while another student was not able to attend due to travel issues.

3.1.2 *Hybrid Cohorts*

Three different cohorts were developed for the hybrid offering, which ran from July 11-15. Cohorts were initially divided using the students preferred campus location, but this resulted in oversubscribed cohorts for Penn State Altoona and UIUC, and an undersubscribed cohort at Michigan Tech. After discussions among the university partners, all ninth grade applicants were cut from these two programs and offered slots in the undersubscribed Michigan Tech cohort. After further discussions, Penn State Altoona and UIUC decided they could accommodate more students with a combination of grant and local funding. The team received several late applications, all of which were offered slots in the Michigan Tech cohort.

These changes resulted in 16 invitations to the Michigan Tech cohort, 27 invitations to the Penn State Altoona cohort, and 22 invitations to the UIUC cohort. As the summer progressed, several students declined participation and others stopped communicating with the team. As positions became available in the Penn State Altoona cohort, they recruited new students from a school with whom they have a special relationship, the Transit Tech High School in Brooklyn.

3.1.3 *Geographic Distribution*

Overall, the summer programs hosted 66 students from 17 different states. Table 3 shows the students' home states, and Figure 3 graphically shows the distribution of states represented in the 2022 program.

Table 3. Student Demographics – Home State

Cohort/State Represented	CT	FL	GA	IL	IN	MA	MD	MI	NC	NJ	NM	NY	OH	PA	TX	VA	WI
MTU Trad				5	1	1	1	9	1	1						2	1
MTU Hybrid			1	2									1		2		1
PSU Hybrid	1	2				1	1		1	2	1	6		4		2	
UIUC Hybrid				14				1		1							
Totals	1	2	1	21	1	2	2	10	2	4	1	6	1	4	2	4	2

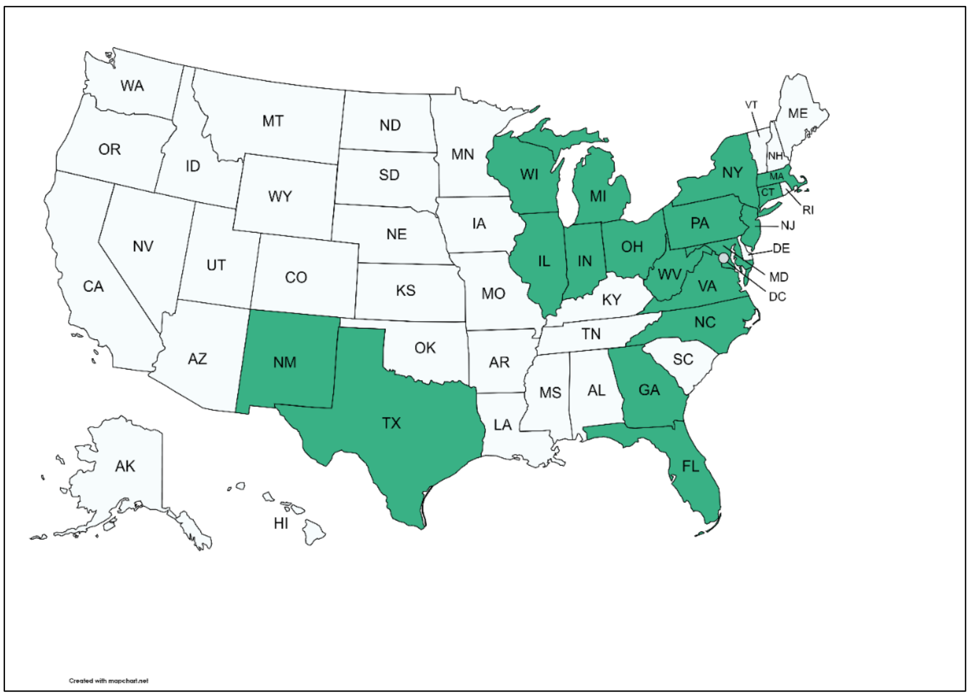

Figure 3. Student Demographics – Home State

4. Curriculum and Educational Methods

4.1 Michigan Tech Traditional Program

Michigan Tech's traditional program featured a full week of on-campus activities, including field trips, hands-on lab activities, and traditional classroom presentations. The 2022 program included local field trips on Monday afternoon and over the Friday lunch period, and an overnight session on Wednesday and Thursday. The classroom activities on Monday and Friday mirrored the sessions planned for the hybrid virtual days, and the hands-on activities on Tuesday were a test run for the same activities during the hybrid sessions.

4.2 Hybrid Program – Virtual Learning Days 1 and 2

The hybrid sessions featured two days of synchronous virtual lessons conducted on the Zoom platform using lesson materials located in Michigan Tech's Canvas learning management system (Figure 4). Sessions included some "traditional lecture" material as well as various online polling and Kahoot! competitions to maintain student interest. The hybrid days also included hands-on activities using materials prepared by program staff and mailed to the students ahead of time (Figure 5), as well as group activities (e.g., internet search tasks and summary activities). Table 4 presents the virtual activity topics, organized into four modules.

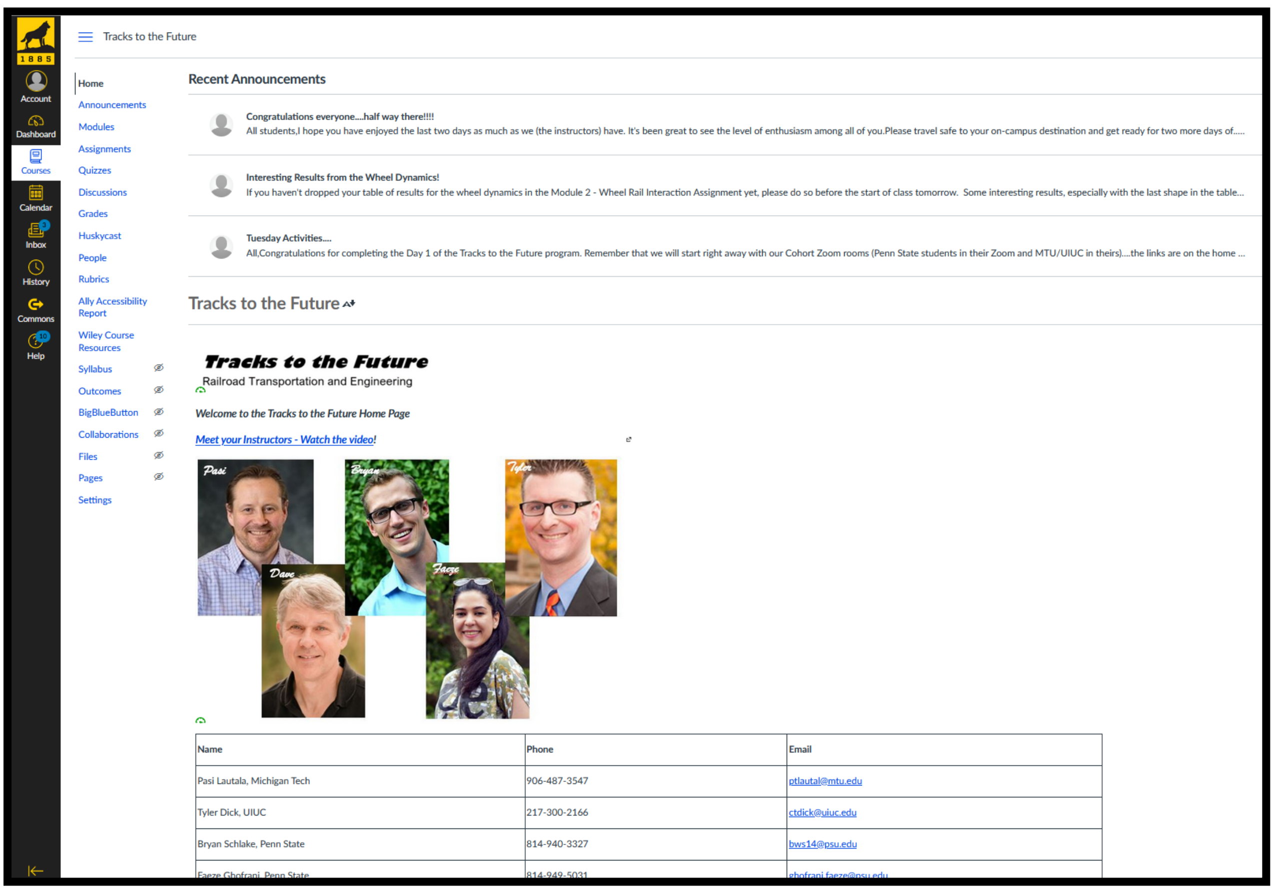

Figure 4. Tracks to the Future Home Page in Canvas

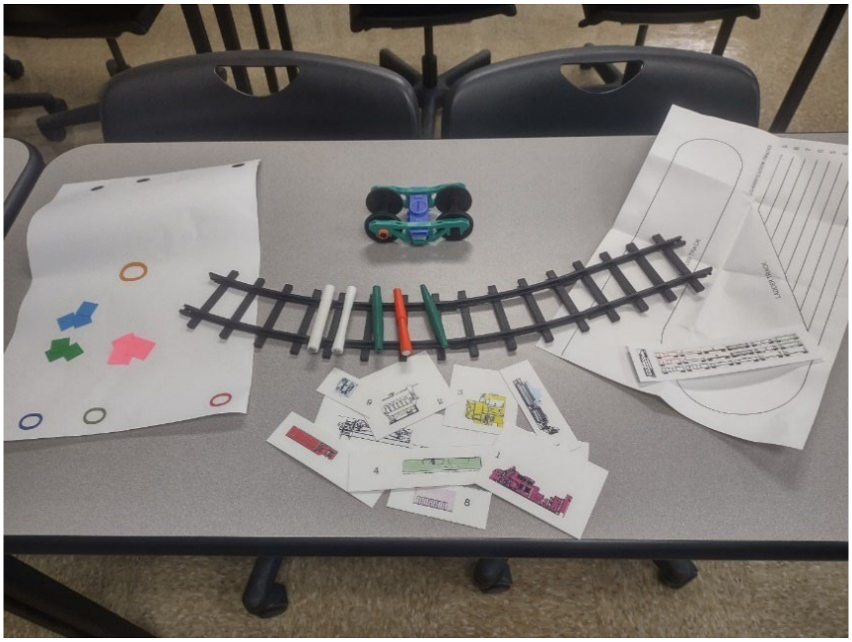

Figure 5. Contents of Mailed Activity Package

Table 4. Hybrid Program – Virtual Curriculum

Module	Content
Pre-course Assignments	• Pre-Knowledge Assessment • Engineering and Belongingness Pre-Survey

1. What is Rail Transportation?	• Intro and History of Rail
	  o Welcome and Rail Industry Jobs
	  o Transportation Modes
	  o Railroad History
	  o What is a Railroad?
	  o Modern Rail

2. Rolling Stock and Locomotives	• Locomotives PowerPoint
	  o Locomotive Puzzle Activity
	  o Wheel Dynamics Activity
	• Railcars PowerPoint
	  o Bogie Parts Activity
	• Braking and Train Energy Management PowerPoint

3. Freight Operations	• Freight Operations PowerPoint
	  o State-To-State Activity
	  o Trucks vs Trains Activity
	  o Yard and Terminal Scavenger Hunt Activity
	  o Classification Yard Sorting Game Activity

4. Passenger Rail	• Passenger Operations PowerPoint
	  o Let's Go for a Trip Activity
	• High Speed Rail PowerPoint
	  o Passenger Rail Options in Foreign Countries Activity
	  o HSR Corridors (China vs US)
	• Urban and Transit Rail PowerPoint
	  o US Commuter Rail System Activity

4.2.1 *Pre-Course Assignments*

The opening module required student to complete two survey documents, the pre-skills knowledge assessment and the pre-belonginess survey. These documents were used to assess whether the material and activities provided in the program produced any change in student knowledge or attitude. The survey documents are included in Appendix B.

4.2.2 *Module 1: What is Rail Transportation*

This module introduced the rail industry. Material was presented synchronously using Zoom, PowerPoint slides, and Kahoot! competitions.

4.2.2.1 Part 1 – Welcome and Rail Industry Jobs

This section comprised two short PowerPoint slide presentations. The first set of slides focused on industry jobs and the railroad programs at each university, and the second introduced the different modes for both freight and passenger operations. A Kahoot! competition occurred during the second PowerPoint presentation.

4.2.2.2 Part 2 – Railroad History and System Components

Two PowerPoint presentations with embedded Kahoot! competition questions were included in this section. The first set of slides presented the history of rail from the early-1800s through the mid-1900s, ending with the Staggers Act in 1980. Kahoot! questions were again used to maintain student interest and engagement. The second presentation provided an overview of railroad operations. Discussion included locomotives and railcars, crew, passengers, cargo, fuel, and the paperwork required to track commodities.

4.2.2.3 Part 3 – Freight and Passenger Rail Transportation Today

The introductory section concluded with a PowerPoint presentation using embedded Kahoot! competitions to examine the effects of the Staggers Act on the railroad industry, including rail consolidations. Group leaders discussed the types of commodities railroads move and introduced some of the attendant infrastructure. The morning sessions ended with an introduction to the different types of passenger rail operations in the US and across the world.

4.2.3 *Module 2: Rolling Stock and Locomotives*

Module 2 focused on the railcars and locomotives used across the rail industry. This module used PowerPoint presentations in Zoom with embedded poll questions and *o* featured two hands-on activities.

4.2.3.1 Part 1 – Locomotives

This section featured a Wheel Dynamics activity, which used 3D printed “cylinders” with different profiles to illustrate the wheel shape used on modern railcars and locomotives. Students rolled the cylinders down a curved track they assembled at home, and noted which shapes managed to stay on track. The student cohort reconvened for a short discussion of their findings.

4.2.3.2 Part 2 – Railcars

The group discussed the parts of a typical railcar and the markings on the sides. An interactive quiz on car parts used a Mentimeter Word Cloud[2] to determine the kinds of railcars with which students were already familiar, and the group discussed the various types and where they were used. The session ended with a discussion of railcar loading and a Kahoot! competition on railcar information.

4.2.3.3 Part 3 – Train Energy Management

This session began with a Kahoot! project on braking and train energy management, followed by a PowerPoint presentation covering the history of rail brakes and how they evolved to today's standards. The session also included a YouTube video of Wabtec's Trip Optimizer system to illustrate train handling concepts. The session ended with a presentation about alternative power systems for locomotives.

4.2.4 Module 3: Freight Operations

The second day of home sessions began with an introduction to freight operations. A PowerPoint was used with Kahoot! competition interspersed throughout the presentation, and several videos and individual and group activities were also included.

4.2.4.1 Part 1 – State to State Freight Movements

This session centered on a group activity using Zoom breakout rooms. Students researched commodity flows between state pairs and reported back to the larger group at the end of the activity.

4.2.4.2 Part 2 – Network Operations, Trucks vs Trains

This session featured an individual guided activity that introduced network operations using materials included in the lesson kit.

4.2.4.3 Part 3 – Freight Rail Terminals

The final session of the freight operations module included two activities. The first featured a small group activity in which students explored and compared a variety of freight rail yards.

In the final freight operations activity, students used a freight yard diagram and a set of paper cars and locomotives to "sort" railcars using a basic sorting process. The instructor also demonstrated geometric and triangular sorting using the same tools, allowing students to follow along on their own freight yards.

4.2.5 Module 4: Passenger Operations

Module 4 was conducted in three parts: Intercity Passenger Rail, High Speed Rail (HSR), and Urban Rail Transit. Each session used a PowerPoint presentation with embedded Kahoot! competitions and also included a variety of student activities, as detailed below.

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[2] https://www.mentimeter.com/templates/word-cloud-template-examples

4.2.5.1 Part 1 – Intercity Passenger Rail

The intercity passenger rail session included a brief discussion of current Amtrak operations and the concept of host and tenant railroads. The session ended with a small group activity where students investigated the time and cost to complete a journey between a US city pair using four different passenger modes (e.g., air, train, etc.). Students returned to the main group to discuss their findings.

4.2.5.2 Part 2 – High Speed Rail (HSR)

This session introduced HSR with a discussion of systems in operation around the world. The group also discussed the optimum HSR operations distance, and HSR implementation challenges related to the distances between many US city pairs. The session included two student activities.

In the first activity, students worked in small groups and researched the operating characteristics of five different rail corridors, each around 200 miles long. Characteristics included the number of daily service options, the time required to complete the route, and the associated costs. The students entered the values in a shared Google sheet, and the activity wrapped up with a guided discussion illustrating the differences between the corridors.

The second activity required students to work in small groups to compare a potential high-speed corridor in the US with an existing corridor in China. The activity highlighted the similarities between distance and population characteristics in this case, illustrating the idea that there are some areas in the US where HSR might make sense.

4.2.5.3 Part 3 – Urban Rail Transit

The final virtual session presented the different types of urban rail systems currently operating in the US and where those systems are found. The session wrapped up with a final activity where students used internet resources to research the characteristics of an assigned transit system. Students returned to the full group session to compare results.

4.3 On-Campus Activities and Field Visits – Days 4 and 5

After virtual modules were completed, students were allowed one day (Wednesday) to travel to their host university for one day of on-campus activities (Thursday) and field visits (Thursday/ Friday). On-campus activities were split between morning and afternoon sessions, and each included three hands-on activities. The field visits introduced students to railroad facilities, and specific locations varied from one university to another.

4.3.1 *Module 5: Morning Session*

On-campus activities were completed in small groups (e.g., 2-3 people) and each group rotated between the three activity sites.

4.3.1.1 Trainz Simulator

Students completed tutorials for the Trainz Railroad Simulator 2019 computer program,[3] then operated trains in the simulator environment (Figure 6). At Michigan Tech, many of the students

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[3] https://store.steampowered.com/app/553520/Trainz_Railroad_Simulator_2019/

returned to the computer lab in the evening on their own time to explore more of the Trainz environment.

Figure 6. Trainz Simulator

4.3.1.2 Wooden Track Operations

Students used Brio[4] track pieces and rolling stock to illustrate rail operations in a game scenario. Starting with a single track with no sidings, students ran trains between two terminals. For each completed operation, students earned "money" that they then used to add infrastructure, including sidings, signals, and additional track.

4.3.1.3 Track Construction

Students built a model track section, including sub-ballast, ballast, ties, and rail, getting a firsthand feel for how adding ballast around the ties stabilizes the structure laterally, longitudinally, and vertically (Figure 7).

Figure 7. Track Model Construction at Michigan Tech (left) and UIUC (right)

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[4] https://www.brio.us/en-US/products/railway-toys

4.3.2 *Module 6: Afternoon Session*

The afternoon session concluded the classroom portion of the program with another round of hand-on activities.

4.3.2.1 Train Resistance and Car Weight & Size

This activity required students to work with a model railcar and a variety of different "load" materials (Figure 8).

Figure 8. Car Weight and Size

In the first part of the activity, students varied the weight of the load and measured the force required to move the car first on a steel rail system and then on a mat designed to simulate a rubber tire on pavement. In the second part of the activity, students used a variety of loads with different densities to illustrate how the volume of some materials can control the capacity of a railcar while the weight of other materials can control the capacity.

4.3.2.2 Mag-Lev

Students worked with magnets to illustrate the attraction and repulsion created between north and south poles, then built a mag-lev car to run on an inclined track. Two tracks were available at each location, and races inevitably occurred!

4.3.2.3 Intermodal Operations

Students again used Brio track pieces and rolling stock to illustrate the difference between truck only and combined truck and rail operations (Figure 9). Students moved containers from a port location to an intermodal terminal using trucks on a highway, moving one container at a time, while a competing group loaded a train with containers double stacked. Loading operations and travel times were compared and discussed.

Figure 9. Intermodal Operations

4.4 Field Trips

Each university provided their own set of field trips for the final day of the hybrid course. The field trips are summarized below.

4.4.1 *Michigan Tech*

The Michigan Tech field trip started on Thursday evening with a bus ride from Houghton to Escanaba (see Figure 10). Students spent the night in an Escanaba hotel, and then visited the Escanaba and Lake Superior car repair shop on Friday morning. The group relocated to Eagle Mills for a tour of the Lake Superior and Ishpeming Railroad facilities, including their car and locomotive shops, dispatch, and a locomotive cab tour. A twenty-minute drive brought the group to Humboldt for a tour of the Eagle Mine rail loadout facility. The students also got a chance to watch the Mineral Range Railroad arrive to pick up a load of nickel and copper concentrate cars. The final stop on the way back to Houghton was at the Pettibone/Traverse Lift company in Baraga for a tour of the shop with the lead design engineer for the Pettibone Speed Swing.

Figure 10. Michigan Tech Student Cohort (On-campus Option)

4.4.2 *Penn State Altoona*

The Penn State Altoona field visits included taking the students to four different railroad engineering educational sites (see Figure 11). The first stop was the Railroaders Memorial Museum in Altoona. This museum showcases not only a variety of historic Pennsylvania Railroad (PRR) rolling stock, but also presents the culture and people who worked on the PRR over the years and how Altoona became a major rail hub in the early 20th century. Students then travelled to the famous Horseshoe Curve where they had lunch and watched Norfolk Southern (NS) freight trains traverse the mountain. Next, students traveled to the Gallitzin tunnels where they watched more NS trains entering/exiting the tunnels and viewed an informational video at in the Visitors Center. Finally, the group stopped at the Allegheny Portage Railroad Museum where students were taught about the early means of traversing the Allegheny mountains via loading canal boats onto railcars that would be pulled up the inclines by cable and across the flat sections by steam locomotives.

Figure 11. Penn State Student Cohort

4.4.3 *UIUC*

The University of Illinois Urbana-Champaign field trip was held at the Monticello Railway Museum, located approximately 25 minutes west of campus (see Figure 12). The students toured the railway, starting with the interlocking tower where museum volunteers explained the fundamental principles of railway signaling and lining routes through interlocking. The students then proceeded to the locomotive shop where they saw the main components of a diesel-electric locomotive and toured several locomotive cabs, with a focus on the various throttle and brake controls. The group then rode one of the museum's newest locomotives to the end of their branch line trackage where the museum stores revenue service equipment for several railcar leasing firms. Instructors and volunteers showed the students the various components of newly delivered tank cars and covered hopper cars, with a focus on the running gear and brake systems. After riding back to the main museum grounds for lunch, the focus shifted from rolling stock to the track. Museum volunteers explained how turnouts work and demonstrated various tools and equipment used to maintain the track structure. Several students took the opportunity to drive spikes into newly replaced crossties. The instructors also explained the advantages and disadvantages of different types of crossties using a section of track at the museum that features timber, concrete, composite, and steel crossties and is used by UIUC Rail Transportation and

Engineering Center (RailTEC) to test field instrumentation procedures. The students then toured the machine shop, wood shop, and paint shop used to maintain the museum's fleet of historic locomotives and railcars, with a focus on some of the specialized tools used to maintain the wheels and running gear.

Figure 12. UIUC Student Cohort

5. Lessons Learned and Recommendations for Next Phase

While Tracks to the Future 2022 built on previous experiences in summer youth programs, it was the first time the program was organized in the new format and at multiple universities. Students provided feedback for both the traditional and hybrid portions.

5.1 Marketing, Coordination and Registrations

The team made the following observations and suggestions for the 2023 program:

- **Develop a master schedule across all universities**. Each university has its own target dates and specific details for the hybrid summer programs. These dates should be clearly identified in advance and incorporated in program materials as much as possible. A single master schedule should guide the various steps in the project.
- **Mitigate disconnect between university registration processes and clarify communication channels**. Various registration processes were used, partially due to differences in the traditional and hybrid programs. This caused confusion among registrants, and at times communication did not occur with the proper entities. The team recommends that all registrations should be initially performed under a single platform.
- **Consider adding registration deposits to discourage dropouts.** While organizers try to minimize the financial burden for students, a high number of students dropped out after registration. Researchers suggest asking for small registration deposits that are refunded if the student participates in the program.
- **Improve demographic data collection in registration forms.** Registration forms did not provide complete demographic data. Also, the main contact was a student email which created a lot of slow (or non) responses. Registration forms should be updated to make sure all demographic data is collected and should require both a student and parent email to encourage timely communication.
- **Improve outreach to female students.** While recruitment of minority students was successful, the same was not true for recruitment of female students. For 2023, there should be an emphasis on outreach to the female student body, such as through the Women in Transportation Society (WTS) and League of Railway Women (LRW).
- **Provide better student travel support.** Several students were provided with travel support, improving their potential for participation in the program. However, administering the support proved logistically challenging. Organizers should work with the accounting office to identify ways to improve the process for 2023.

5.2 Curriculum

Since the curriculum for the traditional program was well established, most recommendations are related to the hybrid curriculum. Overall, the content and teaching methods were well received. Several parents commented that they were amazed how engaged students were with the online material, as several of them had traditionally struggled with remote education activities. Nevertheless, the team made the following observations and recommendations for improvements:

- **Balance content and class time**. More material was made available in the hybrid class work than could be presented, as it was difficult to estimate the time it takes to conduct online learning activities. For 2023, the timing of each module should be reviewed and any omitted activities should be examined for critical information that may have failed to be delivered.
- **Diversity of teaching methods is key for virtual learning**. The use of various teaching methods during virtual learning allowed students to remain engaged in the program. For 2023, the use of activity-based learning and the diversity of teaching methods should be expanded.
- **Resolve Google documents permissions issues**. Using shared documents via Google drive worked much better than downloading documents. However, there were some online permissions issues that need to be solved for 2023.
- **Include prep time before breakout rooms**. Breakout rooms were used successfully in the virtual environment, but students should be given an opportunity to get to know each other before they use this function.
- **Provide more hands-on activities.** Students enjoyed working on activities mailed to them in advance. These activities should be expanded for the hybrid program.
- **Reduce instructor workload.** While the program week was very rewarding for the instructors, program planning and execution was particularly intensive. In future, lead instructors should concentrate on one module for multiple cohorts to reduce their workload.

6. Conclusion

Phase 1 of the *Tracks to the Future: Railroad Transportation and Engineering* summer program was very successful. A total of 66 students from 17 different states participated in the program, the majority of whom were rising high school juniors and seniors, and almost one third representing minorities. However, the program did not attract many female participants.

Based on student feedback, the research team felt the course content was appropriate and the delivery methods kept students interested. Feedback from students and parents was very positive and the remote portions of the hybrid program appeared to maintain student interest. Researchers also saw improvements in railroad knowledge among students in both formats based on before and after assessments.

Weaknesses were identified in recruitment (particularly female), program coordination, registration, and instruction. Improvements will be implemented in Phase 2 (summer 2023) when the hybrid program expands to 120 students and additional colleges. The team plans to expand the program further in Phase 3, adding even more college hosts.

7. References

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Sneider, J. (2022). *Tracks to the Future: Three universities join forces to attract future railroaders*. Progressive Railroading Rail Prime.

NRC (2022). NRC Bulletin: *Tracks to the Future: Railroad Transportation and Engineering, Register Today!*

Appendix A.
Registration Forms and Documents

Tracks To The Future: Railroad Transportation and Engineering

×

For: All students grades 8-11

Dates: June 26-July 1, 2022 (On-Campus)

Applications are now closed. Please check back in Winter 2022 for information about the 2023 cohort.

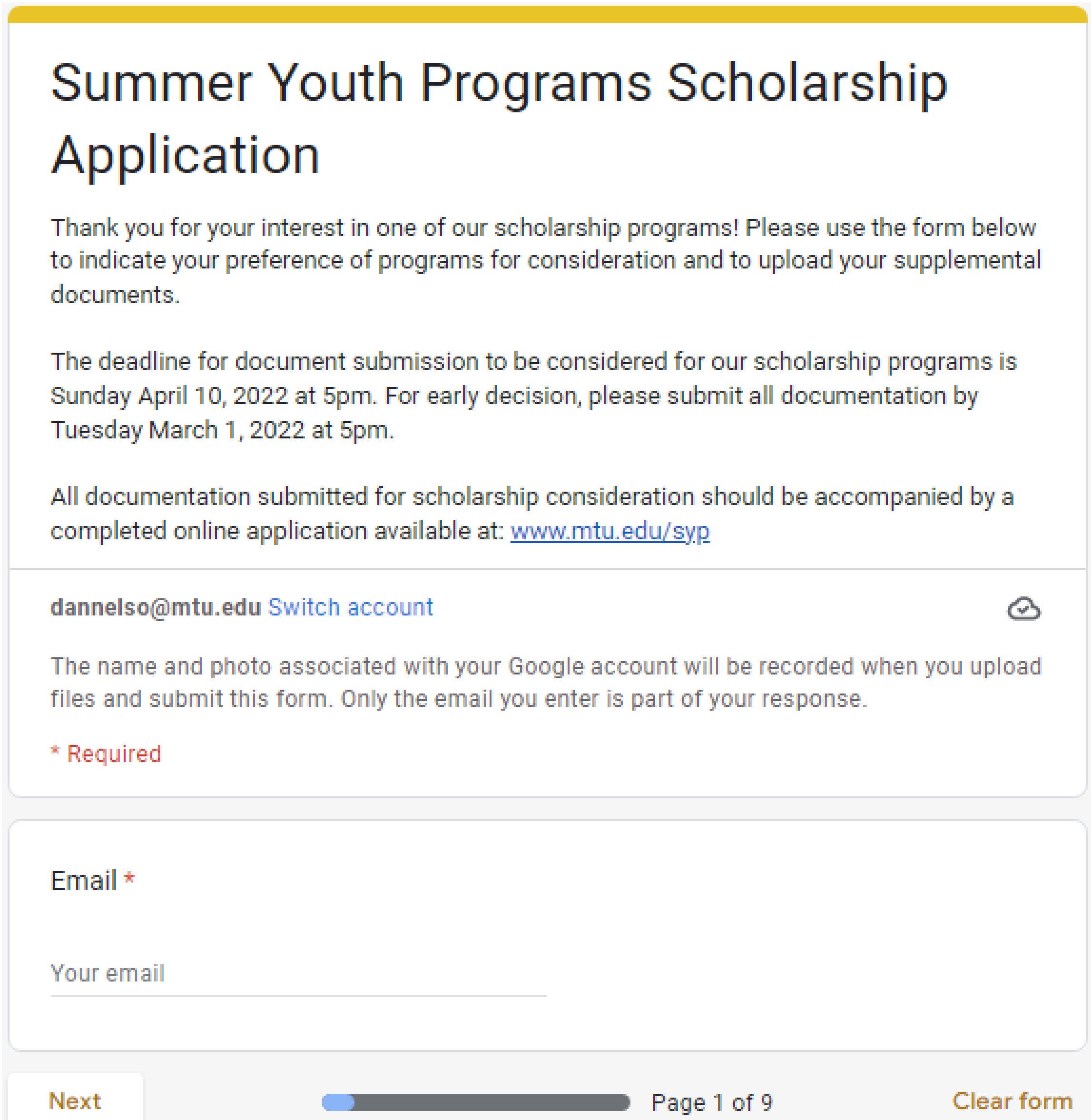
Railroads, the high tech and environmentally sensitive transportation mode! Don't believe us? Come and learn why railroads remain the most energy-efficient mode of transportation and what forms modern railroad track, equipment, and communications/control systems might take. Learn how rail compares with other modes and leads the charge in reducing transportation greenhouse gas emissions! Find out ow it all works through classroom sessions, hands-on activities and field visits to railroad facilities.

Note: Live-in participants only. This exploration will travel to various locations throughout Michigan's Upper Peninsula during the week, and may include an overnight stay in Escanaba, MI.

How to Apply

1. Complete the online SYP application here selecting "Tracks to the Future: Railroad Transportation and Engineering" (CRN 51204) as your program of choice.
   a. When prompted for deposit, click "Mail-In Deposit". Program fees will not be applied until selection decisions are made (within 3 weeks of the deadlines).
2. Provide supplemental documents *either* through our Summer Youth Programs Scholarship Application or by emailing documents to syp@mtu.edu.

Figure 13. Drop Down Box from Michigan Tech SYP



Summer Youth Programs Scholarship Application

Thank you for your interest in one of our scholarship programs! Please use the form below to indicate your preference of programs for consideration and to upload your supplemental documents.

The deadline for document submission to be considered for our scholarship programs is Sunday April 10, 2022 at 5pm. For early decision, please submit all documentation by Tuesday March 1, 2022 at 5pm.

All documentation submitted for scholarship consideration should be accompanied by a completed online application available at: www.mtu.edu/syp

dannelso@mtu.edu Switch account

The name and photo associated with your Google account will be recorded when you upload files and submit this form. Only the email you enter is part of your response.

* Required

Email *

Your email

Next | Page 1 of 9 | Clear form

Figure 14. Michigan Tech SYP Application – Opening Page


TRACKS To THE FUTURE
RAILROAD TRANSPORTATION AND ENGINEERING

Tracks to the Future: Railroad Transportation and Engineering Hybrid Program Application

Thank you for your interest in one of our scholarship programs! Please use the form below to indicate your preference of programs for consideration and to upload your supplemental documents.

The deadline for document submission to be considered for our scholarship programs is April 10, 2022 at 5pm.

Selected applicants will be contacted by their host site to complete registration paperwork.

dannelso@mtu.edu (not shared) Switch account

Next Page 1 of 6 Clear form

Figure 15. Tracks to the Future Hybrid Opening Page of the Application

Appendix B.
Survey Forms

Let's see what you already know about rail …. Name _______________

Instructions: Answer the following questions to the best of your ability, however, please do not guess at an answer. If you really don't know, answer I Don't Know (IDK). If you think you have an answer, but aren't positive, go ahead and give it your best shot! Some of the multiple-choice questions have more than one correct answer, in those cases choose all of the correct ones.

1. Where was the final spike for the transcontinental railroad driven?

A) Promontory, UT	B) San Francisco, CA
C) Omaha, NB	D) New York, NY
E) I Don't Know	

2. List as many large (Class 1) freight railroads in the US as you can? ______
3. List as many passenger rail/transit systems in the US as you can (up to 10)? ______
4. What is the most common freight car in the US today?

A) tank car	B) covered hopper
C) box car	D) flat car
E) I Don't Know	

5. How is a typical modern freight locomotive powered in the US?

A) Nuclear power turns an alternator to create electricity	B) Coal burns to heat water to steam
C) A diesel engine turns an alternator to create electricity	D) A gasoline engine drives a mechanical transmission
E) I Don't Know	

6. Railroad wheels are shaped like:

A) Flat cylinders	B) Cones
C) I Don't Know	

7. How is a typical bogie set held together?

A) Welding	B) Gravity
C) High strength bolts	D) Super glue
E) I Don't Know	

8. The average freight rail shipment in the US moves __________ miles.
9. The typical US Class 1 railroad freight train is ________ cars long
10. Most freight cars move directly from origin to destination on a single freight train. T/F/IDK
11. Amtrak owns all of the rail lines it operates on. T/F/IDK
12. Most passenger trains in the North America operate at speeds over 100 mph T/F/IDK
13. Rubber truck tires have more resistance than steel train wheels. T/F/IDK
14. What does the ballast do in a track system?

A) Holds the track down to the ground	B) Keeps the ties from moving longitudinally
C) Provides vertical support underneath the sleepers	D) Provides drainage through the system
E) I Don't Know	

15. Diesel engines drive the wheels that make the maglev move forward. T/F/IDK
16. If you have a freight car with a nominal capacity of 110,000 pounds what is the maximum gross rail load?

A) 220,000 pounds	B) 263,000 pounds
C) 286,000 pounds	D) 315,000 pounds
E) I Don't Know	

17. Trains are very efficient, so it doesn't take a lot of accelerating force or braking effort to start and stop them. T/F/IDK
18. The number of trains per day that can travel across a single-track corridor is primarily dependent on siding length and location. T/F/IDK
19. Trucks are more effective for long-haul and high-volume transportation than rail T/F/IDK

Figure 16. Pre Program Knowledge Survey

Let's see what learned about rail …. Name _______________

Instructions: Answer the following questions to the best of your ability, however, please do not guess at an answer. If you really don't know, answer I Don't Know (IDK). If you think you have an answer, but aren't positive, go ahead and give it your best shot! Some of the multiple-choice questions have more than one correct answer, in those cases choose all of the correct ones.

1. Where was the final spike for the transcontinental railroad driven?

A) Promontory, UT	B) San Francisco, CA
C) Omaha, NB	D) New York, NY
E) I Don't Know	

2. List as many large (Class 1) freight railroads in the US as you can? ______
3. List as many passenger rail/transit systems in the US as you can (up to 10)? ______
4. What is the most common freight car in the US today?

A) tank car	B) covered hopper
C) box car	D) flat car
E) I Don't Know	

5. How is a typical modern freight locomotive powered in the US?

A) Nuclear power turns an alternator to create electricity	B) Coal burns to heat water to steam
C) A diesel engine turns an alternator to create electricity	D) A gasoline engine drives a mechanical transmission
E) I Don't Know	

6. Railroad wheels are shaped like:

A) Flat cylinders	B) Cones
C) I Don't Know	

7. How is a typical bogie set held together?

A) Welding	B) Gravity
C) High strength bolts	D) Super glue
E) I Don't Know	

8. The average freight rail shipment in the US moves __________ miles.
9. The typical US Class 1 railroad freight train is ________ cars long
10. Most freight cars move directly from origin to destination on a single freight train. T/F/IDK
11. Amtrak owns all of the rail lines it operates on. T/F/IDK

Figure 17. Post Program Knowledge Survey

Belongingness & Identity Pre Survey

The following survey consists of 16 multiple choice questions. Circle the best answer for each.

1. A career in rail transportation/engineering will give me the kind of lifestyle I want.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

2. A degree related to rail transportation/engineering will allow me to get a job where I can use my talents and creativity.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

3. A degree in rail transportation/engineering will allow me to obtain a job that I like.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

4. I can relate to people around me in this summer program.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

5. I have a lot in common with the other students in this summer program.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

6. The other students in this summer program share my personal interests.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

7. My parents see me as a rail transportation engineer.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

8. My instructors see me as a rail transportation engineer.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

9. My peers see me as a rail transportation engineer.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

10. I am interested in learning more about rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

11. I enjoy learning about rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

12. I find fulfillment doing rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

13. I am confident that I can understand rail transportation/engineering in this program.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

14. I am confident that I can understand rail transportation/engineering outside of this program.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

15. I understand concepts I have studied in rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

16. Others ask me for help in rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

Figure 18. Belongingness and Identity Pre Program Survey

Belongingness & Identity Post Survey

The following survey consists of 16 multiple choice questions, followed by three open-ended questions. Circle the best answer for each of the multiple choice questions. Then, please provide a response for each open-ended question.

1. A career in rail transportation/engineering will give me the kind of lifestyle I want.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

2. A degree related to rail transportation/engineering will allow me to get a job where I can use my talents and creativity.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

3. A degree in rail transportation/engineering will allow me to obtain a job that I like.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

4. I can relate to people around me in this summer program.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

5. I have a lot in common with the other students in this summer program.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

6. The other students in this summer program share my personal interests.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

7. My parents see me as a rail transportation engineer.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

8. My instructors see me as a rail transportation engineer.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

9. My peers see me as a rail transportation engineer.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

10. I am interested in learning more about rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

11. I enjoy learning about rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

12. I find fulfillment doing rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

13. I am confident that I can understand rail transportation/engineering in this program.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

14. I am confident that I can understand rail transportation/engineering outside of this program.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

15. I understand concepts I have studied in rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

16. Others ask me for help in rail transportation/engineering.

1–Strongly Disagree 2–Disagree 3–Somewhat Disagree 4–Neutral 5–Somewhat Agree 6–Agree 7–Strongly Agree

17. How did this program affect your identity as a potential transportation engineer?
18. How did this program affect your sense of belonging within the railroad industry?
19. Please tell us what areas in transportation engineering interest you in terms of future career paths.

Figure 19. Belonginess and Identity Post Program Survey

Abbreviations and Acronyms

ACRONYM	DEFINITION
AREMA	American Railway Engineering and Maintenance of Way Association
FRA	Federal Railroad Administration
HSR	High Speed Rail
Michigan Tech	Michigan Technological University
NRC	National Railroad Construction and Maintenance Association
NS	Norfolk Southern Railway
PRR	Pennsylvania Railroad
Penn State Altoona	Pennsylvania State University at Altoona
SYP	Summer Youth Program
UIUC	University of Illinois, Urbana-Champaign