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Innovative Educational Modules for the Next Generation of Transportation Professionals

Final Report

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16. Abstract:

Basic science and mathematics competence, including awareness of engineering careers, gained in grades K–12 forms the foundation of an educated, capable, and technical future transportation workforce. This project developed a series of educational science, technology, engineering, and math (STEM)-based modules for grades 6–12. These modules engage students in real-world applications of math, deductive reasoning, and problem solving. The modules can be incorporated in either the classroom or informal educational settings, such as afterschool enrichment programs. The modules created by this project can be found at http://www.transportationoutreach.org.

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INNOVATIVE EDUCATIONAL MODULES FOR THE NEXT GENERATION OF TRANSPORTATION PROFESSIONALS

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to Prepare Our Next Generation of Transportation Professionals

University Transportation Center for Mobility™
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Executive Summary

Studies continue to show a downward trend by U.S. students in their knowledge of science, technology, engineering, and mathematics (STEM) subjects and their view of engineering as a future career. Basic science and mathematics competence, including awareness of engineering careers, gained in grades K–12 forms the foundation of an educated, capable, and technical future workforce needed by transportation agencies and the transportation field as a whole. The current and future success of the transportation infrastructure and its diverse array of components depend on developing a workforce that is able to design, plan, manage, operate, and maintain the vast infrastructure in place.

Statewide in 2005–2006, only around 20% of Texas public school graduates enrolled in Texas public universities. Rural students are even less likely to pursue higher education than their urban counterparts. Motivations for students to attend college include supportive influence by parents and peers, accurate value assessment of higher education, high school activity, and socioeconomic/demographic factors. These motivations are often missing for many students.

The STEM-based modules created for this project are intended to provide educators a way to engage students in real-world applications of math, deductive reasoning, and problem solving. It is envisioned that the modules may be used in both formal and informal educational settings. By creating enjoyable and engaging learning activities that address real-world issues through the application of mathematics and technology, the modules can increase students' mathematics competence as well as introduce them to current issues in transportation.

All of the modules developed by the project team were designed to promote both STEM and awareness of transportation career opportunities in each of the subject matter areas. The three focus areas selected for these modules were aviation, radio frequency identification technology, and cargo/freight transportation.

Every module consists of a PowerPoint presentation, background material fact sheets, worksheets and activities, and a series of links for more information. Each of the modules was reviewed by local educators to ensure that it is appropriate for the targeted grade levels. The completed modules can be found at http://www.transportationoutreach.org.

Chapter 1: Background

Document Overview

Studies continue to show a downward trend by U.S. students in their knowledge of science, technology, engineering, and mathematics (STEM) subjects and their view of engineering as a future career. Basic science and mathematics competence, including awareness of engineering careers, gained in grades K–12 forms the foundation of an educated, capable, and technical future workforce needed by transportation agencies and the transportation field as a whole. The current and future success of the transportation infrastructure and its diverse array of components depend on developing a workforce that is able to design, plan, manage, operate, and maintain the vast infrastructure in place.

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Scope and Purpose

The main objective of this project was to facilitate outreach strategies that emphasize STEM to students in an engaging manner that will stimulate interest in STEM careers. A secondary objective was to introduce students to career opportunities in transportation.

Intended Audiences and Uses

The completed modules for this project present information on areas of transportation research. The target audiences for the modules are students in grades 6–8. Research shows that students begin considering career paths as early as 11 years old, and most have an idea of a career direction they want to focus on by the 10th grade. Young people, both students and those just out of school, draw on a number of sources when making decisions regarding careers. By providing outreach strategies to all Texas students that emphasize STEM and introducing them to transportation opportunities and careers, this project encourages students to explore careers in both transportation and STEM.

The modules from this project are intended for use in both classroom and outreach settings, as well as individual career exploration opportunities via the www.transportationoutreach.org website.

Chapter 2: Methodology

The transportation industry, like every other profession that relies heavily on the STEM fields, faces a growing shortage of professional engineers. In order to maintain a competent and capable workforce, students must be made aware of the importance of STEM subjects. Students must be also made aware of the opportunities available to those who choose engineering and transportation as a future career. Basic science and mathematics competence, gained in grades K–12, especially during the formative middle school years, form the foundation of an educated, capable, and technical future workforce. The current and future success of the transportation infrastructure and its diverse array of components depend on developing a workforce that is able to design, plan, manage, operate, and maintain the vast infrastructure in place.

This project incorporated a number of transportation research focus areas into educational modules for grades 6–12. As previously stated it is anticipated that these STEM-based modules will provide educators a way to engage students in real-world applications of math, deductive reasoning, and problem solving. It is envisioned that the modules can be used in both formal and informal educational settings. By creating enjoyable and engaging learning activities that address real-world issues through the application of mathematics and technology, the modules can increase students' mathematics competence as well as introduce them to current issues in transportation.

Each module presents basic information on a transportation topic and provides background material fact sheets. Both activity worksheets, such as crossword puzzles, word searches, and match games, and hands-on activities are provided in the module to reinforce the concepts presented. Links to follow-up activities and more detailed subject information are also provided.

Chapter 3: Aviation Module

Overview

The first module developed as part of this project was an educational module on aviation and the scientific principles of flight. This module consists of a PowerPoint presentation, background material fact sheets, worksheets and activities, and a series of links for more information. A summary of the fact sheets and materials presented is included below.

Principles of Flight

In order to understand the principles of flight, a number of key scientific principles must be understood. Flight, simply put, can occur when an object is lighter than the air around it. The object floats in the air, and when forward motion is applied, flight occurs. However, when the object is heavier than the air, the physics get tricky.

There are a number of forces that act on heavier-than-air flying objects. These forces, which are graphically depicted in Figure 1, are:

- **Thrust:** Thrust is the force that propels an object forward. Propellers and jet engines provide thrust for planes. A bird creates thrust by flapping its wings.
- **Drag:** Drag is caused by air hitting the surface of a flying object. This creates friction and slows the object down. The force of drag operates in the opposite direction from thrust.

- **Gravity:** Objects near the earth's surface are pulled downward by the earth's gravitational field. If gravity were the only force operating, no object heavier than air would be able to leave the ground.
- **Lift:** Any force that operates against gravity can be called lift. If an object is to rise above the earth, the lifting force must be greater than gravity. For an object to hover, like a dragonfly or helicopter, the upward force of the lift must equal the downward force of gravity.

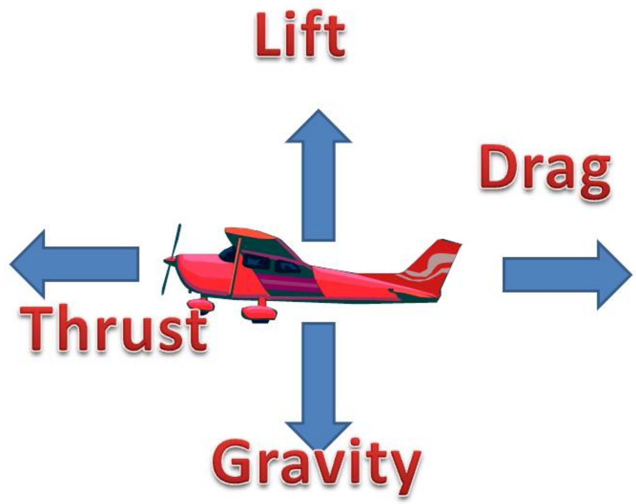

Figure 1. Forces That Affect Flight

The Bernoulli Effect

In the 1700s, a famous mathematician named Daniel Bernoulli wanted to know how fluids flow. In particular, he and his friend Leonhard Euler wanted to know about blood flow and pressure. Bernoulli created an experiment where he punctured the wall of a pipe with a small open-ended straw and found that the height that fluid rose in the straw was related to the fluid pressure in the pipe. Figure 2 is a graphic representation of this experiment. To this day, Bernoulli's method of measuring pressure is used to measure the air speed of a plane.

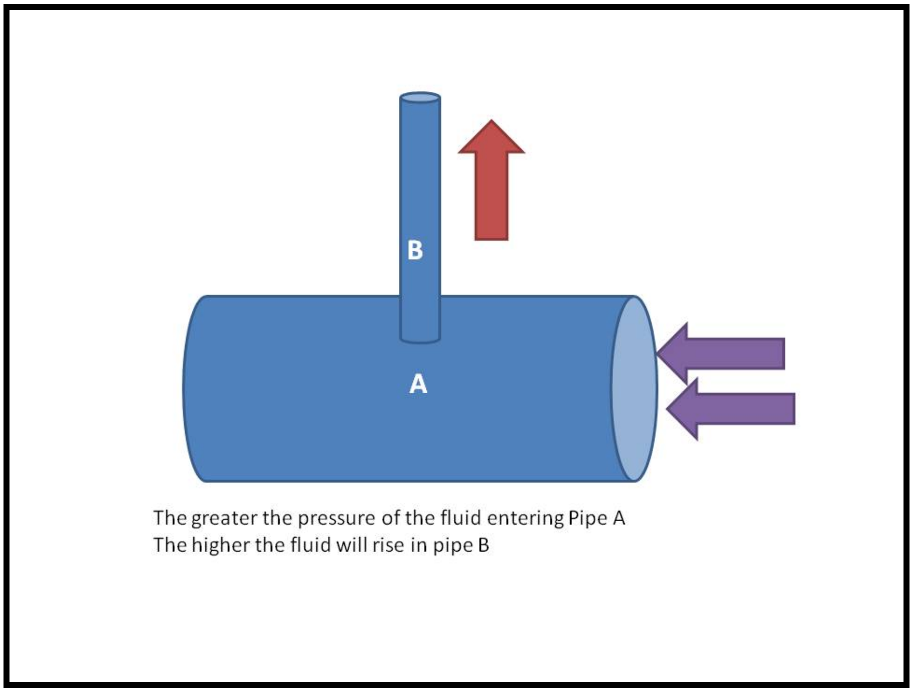

Figure 2. Fluids and Pressure

Bernoulli then began to study birds and their flight. He began to apply his knowledge of fluid and pressure to analyze how a bird's wing works. He found that air flows faster over the top of a curved wing than below the wing. The faster airflow over the wing reduces pressure above the wing. This causes the wing to lift, as shown in Figure 3. This phenomenon is known as the Bernoulli Effect.

In addition to the above discussion on the scientific principles that led to human flight, the presentation provides a historical timeline for human flight and modern aviation. This timeline begins with the first recorded human flight in 1783, a balloon flight by the Montgolfier brothers. The presentation then examines the dirigible, which is a lighter aircraft that is both powered and steered. The flight by the Wright Brothers is then presented along with the first transatlantic flight, by Charles Lindbergh. Jet aircraft are presented next with attention focusing on the first flight that broke the sound barrier, by General Chuck Yeager, in 1947. Space travel beginning with the first solid fueled rocket through the Kepler mission in 2009 is also examined.

Activities and links that encourage further exploration of aviation are also provided at the end of the module.

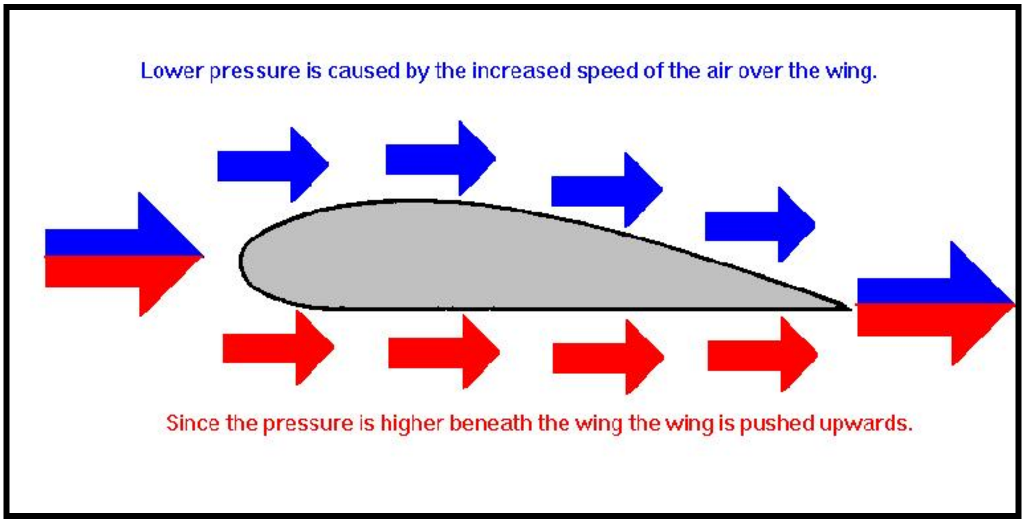

Figure 3. The Bernoulli Effect

Chapter 4: RFID Module

Overview

The second educational module developed is on the topic of radio frequency identification (RFID). This module also consists of a PowerPoint presentation, background material fact sheets, worksheets and activities, and a series of links for more information. A summary of the fact sheets and materials developed is presented below.

RFID Technology

RFID is utilized in many different ways. This technology uses the communication radio waves to exchange data between a reader and an electronic tag attached to an object. The tag is used for the purpose of identification and tracking. RFID makes it possible to give each product in a grocery store its own unique identifying number; it can also be used to provide such things as assets, people, work in process, farming, and medical devices with individual unique identifiers.

It has been said that radio frequency identification technology history can be traced back as far as World War II. The Germans, Japanese, Americans, and British all used radar, which was discovered in 1935 by Scottish physicist Sir Robert Alexander Watson-Watt. His invention helped them to identify approaching planes while they were still miles away. The problem was that military units had no way to identify which planes belonged to the enemy and which were their own pilots returning to base. In 1945, Léon Theremin invented an espionage tool for the Soviet Union that retransmitted incident radio waves with audio information. Sound waves vibrated a diaphragm that slightly altered the shape of the resonator, which modulated the reflected radio frequency. Even though this device was a covert listening device, not an identification tag, it is considered a predecessor of RFID technology because it was likewise passive, being energized and activated by electromagnetic waves from an outside source.

Components of an RFID System

RFID can be viewed as a competitor to the barcode, or a more advanced technology than the barcode. Today, in many cases, the barcode remains the better solution, particularly in the short to medium term. However, RFID has many advantages; for example, the reader and tag do not have to be in direct line of sight, the tag can contain serial number information as well as product data, and RFID tags can be made much more rugged and durable. Product data that is part of RFID is known as Electronic Product Codes (EPC). The major downside at present is the price of individual RFID tags and the system setup costs (1). A comparison of barcodes versus RFID is found in Table 1.

Table 1. Comparison of Barcode vs. RFID/EPC (1)

	Barcodes	**RFID/EPC**
Positive	*Low Cost *Broad Utilization *Human Readable	*No Line of Sight *Large Memory—Data Moves with Product/Asset *Dynamic Data Reads
Negative	*Data Transfer Requires Line of Sight *Data Storage Is Limited *Environmentally Sensitive	*Higher Costs *Read Sensitive to Product Attributes *Limited Adoption

RFID technology consists of the components of a reader, an antenna, an active/passive tag(s), a battery-assisted passive (BAP) tag, or a semi-passive tag. A typical RFID system is depicted in Figure 4. There are two types of readers: a fixed reader and a mobile reader. A fixed reader is mounted to an object (e.g., a post or pole) and creates a funnel with its waves, through which it identifies a tag when the tag passes the reader. A mobile reader is usually a handheld device or one attached to an automobile or cart that allows the reader to identify tags that could possibly be stationary. Some of the companies that manufacture the readers and antennas are Motorola, Impinj, Sirit, and RF Code.

The antennas for high frequency (HF) and ultra-high frequency (UHF) tags can be etched onto a flexible plastic base for affixing as an adhesive label to a case or pallet. RFID tags can even be embedded into a product at the time of manufacture (1).

An RFID reader contains a power supply and software to enable it to communicate with both RFID tags and an upstream computer system. Handheld readers are similar in size to personal digital assistants (PDAs), while others form part of a fixed installation (2).

Middleware is needed to form an interface between the reader and enterprise software systems such as warehouse management systems (WMSs). RFID results in considerably increased volumes of data within the enterprise; the increase comes about through the addition of serial number information to each individual record and a greatly increased number of data records (2).

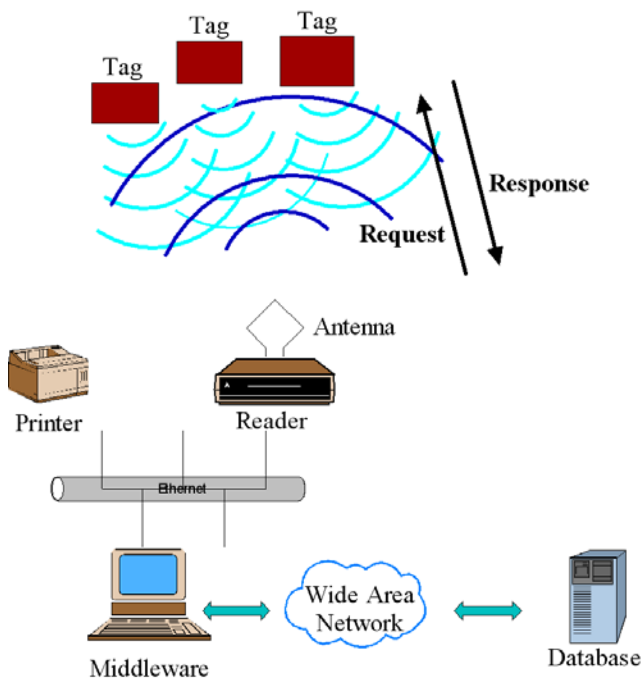

Figure 4. Typical RFID System (3)

There are many different tags, and they have many uses. There are active and semi-passive RFID tags that use internal batteries to power them. An active tag uses its battery to broadcast radio waves to a reader, whereas a semi-passive tag relies on the reader to supply its power for broadcasting. Active RFID tags are more expensive than passive tags. Active and semi-passive tags are reserved for costly items that are read over greater distances; they broadcast high frequencies from 850 to 950 MHz that can be read 100 ft or more away. Passive tags use the reader to power the source and can be read 20 ft away. The passive tag costs less and is disposable, just like the product to which it is tagged. Assortments of active and passive tags are shown in Figure 5.

Radio frequency identification can be used in many different industries, such as medicine, logistics, toll roads, animal tracking, and many others. This technology can be used for such things as elevating the use of credit cards and helping locate lost pets and other animals that run away or are stolen. The use of RFID technology will continue to increase over time.

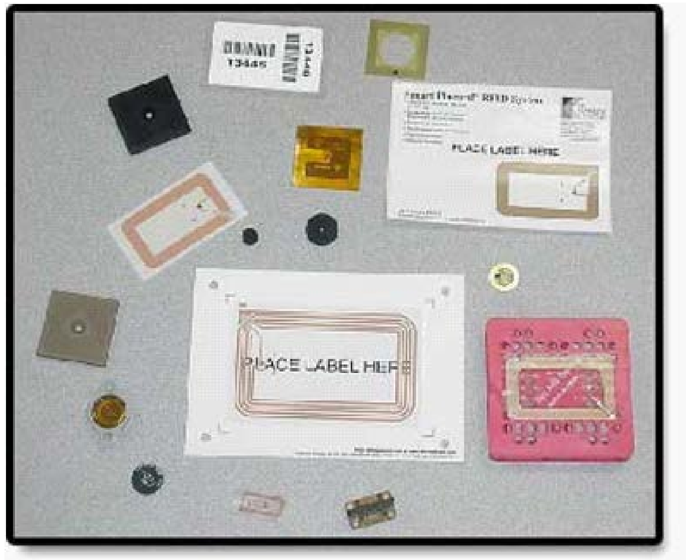

Figure 5. RFID Active and Passive Tags

RFID Use in the Transportation Industry

RFID has been used in the transportation field since the mid-1990s. The primary use of RFID in the transportation field is toll collections on toll roads. RFID is used to collect tolls on highways to improve traffic and ease congestion. RFID systems have been proven to process as many as 2,200 cars an hour, while a manual tollbooth can process only 400 cars per hour. The RFID toll collection system operates by drivers purchasing the RFID tag with a unique identification number and an account. That account is charged when the driver passes under an RFID reader, which is usually placed above the highway. This system has been constantly evolving to accommodate more drivers. Originally, drivers had to purchase expensive RFID tags with batteries that would be dead within three years. Now, most of the RFID tags are less expensive and can be installed easily. For example, passive tags that are just stickers can be easily placed on a windshield. Currently, there are more than 10 million RFID tags around the world used in cars (4).

Furthermore, with the large network of cars with RFID tags, transportation agencies have been using this technology for traffic management and information access. This system has been used to track the travel time of individual cars as they pass roadside readers and then create an average trip time on state roads. This average travel time is then displayed for the public on dynamic message signs to provide up-to-date traffic information.

One impressive application of the RFID toll system was implemented by the Utah Department of Transportation (UDOT) in late 2010. UDOT included this system on high occupancy vehicle (HOV) lanes to decrease traffic in more congested areas. In addition, UDOT is the first department of transportation in the United States to use EPC Gen 2 passive UHF RFID tags. UHF RFID tags can be identified at speeds up to 110 mph from 20 ft or more above the highway. However, the most impressive quality of these tags is their ability to be turned on and off. Since the system is on an HOV lane, UDOT wanted a tag that could be turned on when a driver is alone and then turned off when there are more passengers in the car. The agency also included a red light feature for the highway patrol officers to identify when tags are turned off. Therefore, single drivers that are trying to cheat the system can be identified and ticketed (5).

There have been several other innovate ideas proposed for the implementation of RFID in transportation, like RFID tags on license plates. However, due to individual states' privacy laws, ideas like RFID tags on license plates have been rejected. Nevertheless, RFID is evolving in the field of transportation.

Activities and links that encourage further exploration of RFID technologies are also provided at the end of the module.

Chapter 5: Freight/Cargo Module

Overview

An educational module on cargo movement and transportation career opportunities in freight and logistics was also developed. Like the other modules, this module consists of a PowerPoint presentation, background material fact sheets, worksheets and activities, and a series of links for more information. A summary of the fact sheets and materials presented is included below.

The cargo transport presentation is intended as a resource to help teachers and instructors lead discussions with middle and high school students about the modes and global role of cargo transport, how it affects peoples´ daily lives, and potential future career opportunities for students.

Cargo Transportation

The module begins by describing transportation in general and then focuses on cargo transportation more specifically. The objective is to help students think about the role of cargo transportation in their daily lives. There are two primary motivations for this approach. First, the images and concepts are selected for their relevance to the daily lives and interests of students or aspects of daily life they are regularly exposed to. Second, the images and concepts are selected to represent the global nature of cargo transportation by different modes and in different applications.

In an attempt to depict the importance of cargo transport and supply chains in everyday life, two examples are used—energy supply chain and food supply chain. These depictions are examples of cargo transport in specific, tangible settings and convey the idea that cargo transport is relevant to everyone as well as the role that cargo transport plays in global society.

The first supply chain sequence traces the energy (gasoline fuel) supply chain. Crude oil is transported by bulk tanker ship or pipeline to refineries, from refineries to fuel storage terminals, and by truck from storage terminals to gasoline fueling stations. The second supply chain sequence follows an agricultural (grain) supply chain. Food is harvested on farms and transported by truck or rail to processing facilities, such as bread or cereal factories. From there, finished products are transported to market, and the controlled conditions under which food items must be kept are noted. The final portion of the examination of supply chains' transportation follows production of finished goods to sales locations and notes the importance of on-time logistics in supply chains.

The module then describes the different modes of cargo transport. First, the five modes—pipelines, ships, airplanes, railroads, and trucks—are presented, and then each of the modes is individually discussed. The type of cargo that is handled by each specific mode varies. Brief examples for each mode are also discussed these provide an extension or linkage to a larger sense of community and development for supply chains. For pipelines, the importance of safety and the call-before-you-dig message is noted. The historical importance of trade by ships is mentioned. For airplanes, time sensitivity and relative transport cost per amount of cargo are discussed. Railroads' role in the westward settlement of the U.S. is described. Finally, trucks' flexibility in moving cargo over short or long distances is reviewed.

The final portion of this module provides examples of potential jobs and careers that engineers, scientists, and technicians can have in cargo transportation. The presentation introduces these career paths and talks about how they are applicable for designing, building, improving, and maintaining vehicles and vessels, operating systems, and infrastructure.

Activities and links that encourage further exploration of cargo and freight transportation careers are also provided at the end of the module.

Chapter 6: Summary and Conclusion

All of the modules developed by the project team were designed to promote awareness of both STEM and transportation career opportunities in each of the subject matter areas. The three focus areas selected for these modules were aviation, radio frequency identification technology, and cargo/freight transportation.

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Chapter 7: References

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