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MINETA TRANSPORTATION INSTITUTE

The Central Valley Transportation Challenge

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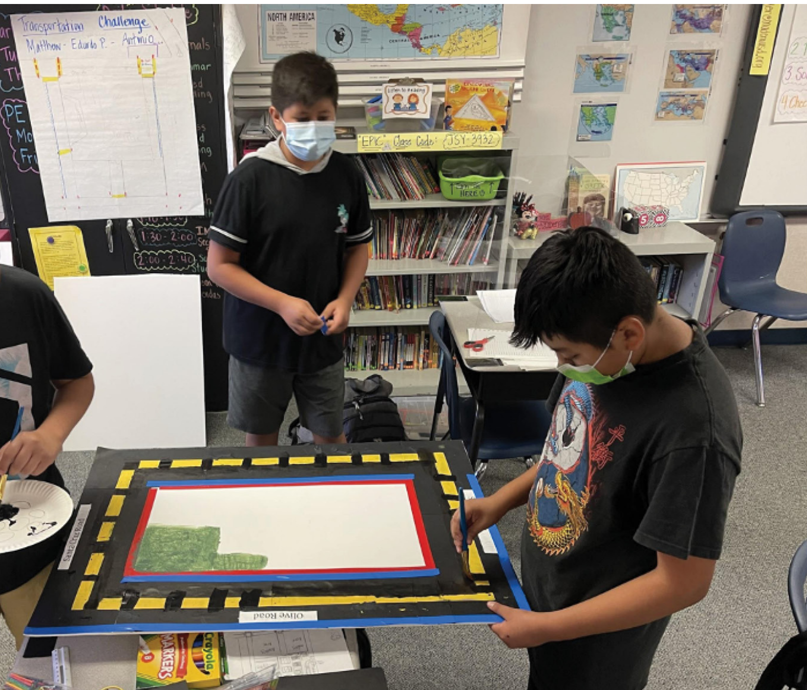

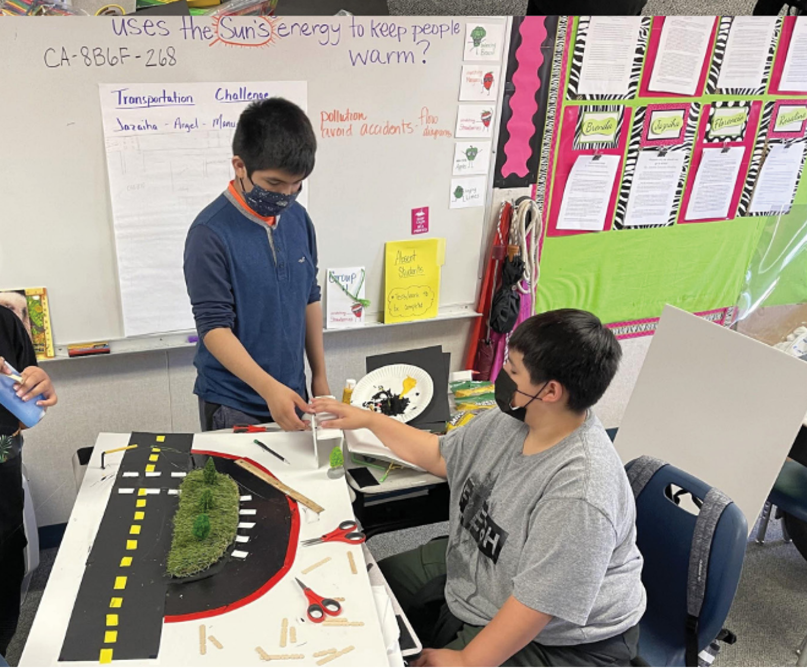

CSUTC California State University Transportation Consortium

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Founded in 1991, the Mineta Transportation Institute (MTI), an organized research and training unit in partnership with the Lucas College and Graduate School of Business at San José State University (SJSU), increases mobility for all by improving the safety, efficiency, accessibility, and convenience of our nation's transportation system. Through research, education, workforce development, and technology transfer, we help create a connected world. MTI leads the Mineta Consortium for Transportation Mobility (MCTM) funded by the U.S. Department of Transportation and the California State University Transportation Consortium (CSUTC) funded by the State of California through Senate Bill 1. MTI focuses on three primary responsibilities:

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The Central Valley Transportation Challenge provides underserved minority students, who are primarily from rural areas, with high quality transportation-related educational experiences so that they learn about transportation-related topics and opportunities in transportation careers. The CVTC is a project-based learning program that brings university faculty and students to K–12 classrooms in rural areas. The project operated with three main objectives: (1) support K–12 teachers' understanding and implementation of the CVTC programs; (2) connect K–12 students with university faculty and students, and transportation professionals through the CVTC program; and (3) develop an online hub with transportation-related lesson plans and sequences. The results of this study are reported as five case studies and a description of the online hub. The case studies illustrate how different pedagogical approaches and uses of technology were implemented and how the project connections between the schools, community members and professionals from transportation-related fields were developed. In addition, to support the sustainability of transportation-related learning across subsequent years, the research team created an online transportation resource repository. This hub was populated with lessons and units developed by pedagogical and content experts. The lessons cover the grades K–12 and range from brief lessons to very engaging and holistic two-week-long lesson sequences. The CVTC has proven to be a highly flexible and adaptive model due to the use of technology and the teachers' experience and pedagogical expertise. The timing of the program during the COVID-19 pandemic also provided the students that were learning from home with an engaging learning experience and some relief for teachers who were already dealing with a lot of adjustments. In that sense, the program reached traditionally underserved students, but did so in a critical time where these students faced even more obstacles.</td></tr>
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Executive Summary

The Central Valley Transportation Challenge (CVTC) aimed to provide underserved minority students, who are primarily from rural areas, with high quality transportation-related educational experiences, so that they learned about transportation-related topics and opportunities to examine transportation-related careers. The CVTC is a project-based learning program that connects university faculty and students to the K–12 classrooms in rural areas. Because of the focus on rural areas the project already planned to leverage technology, but the COVID-19 pandemic took the use of technology to an unprecedented level. The initial process and goals of the project were adapted to the circumstances. Nevertheless, the CVTC has proven to be a highly flexible and adaptive model, both in its use of technology and in the teachers' abilities to adapt to the situation, owing to their experience and pedagogical expertise.

The project goals were accomplished through three main objectives that intersect within the CVTC program. First, the project supported K–12 teachers' understanding and implementation of the CVTC programs. Second, the project connected K–12 students with university faculty and students, and transportation professionals through the CVTC program. These interactions created opportunities for students to explore transportation topics and deepen students' knowledge in meaningful and authentic contexts. Third, the project developed an online hub with transportation-related lesson plans and lesson sequences.

The results are reported as five case studies and a description of the online hub. The case studies illustrate how different pedagogical approaches and uses of technology were implemented and how the project connections between the schools, community members, and professionals from transportation-related fields were developed. Also, to support the sustainability of transportation-related learning across subsequent years an online transportation resource repository was created. This hub was then populated with lessons and units developed by pedagogical experts and content experts. The lessons cover the grades K–12 and range from brief lessons to very engaging and holistic two-week-long lesson sequences.

Overall, the CVTC program has turned out to be a very resilient program with a wide variety of pedagogical and technological approaches, also because it had to be adapted to fit the difficult time during COVID.

The timing of the program during COVID also provided the students that were learning from home with an engaging learning experience and some relief for teachers who were already dealing with a lot of adjustments. In that sense the program did not only reach underserved minorities, but did so also in a time where these students were further disadvantaged. The online transportation hub with the lesson repository will endure this project and make the project's impact sustainable.

1. Introduction

The complexity of a globalized world, accelerating technological advances, and rapid change, all challenge educational systems. Around the world, the call is to develop twenty-first century skills with a focus on career readiness, ability for lifelong learning, and collaboration skills (Avanzado & Claro, 2009). Project-based service-learning has been identified as an approach to develop these skills (Furco & Root, 2010). At the same time, the Southwest Transportation Workforce Center (SWTWC) has identified a particular need in workforce development for the transportation industry. The National Transportation Career pathways report of (SETWC, 2019) highlights "the fundamental lack of engagement at the K–12 and community college level unnecessarily restricts awareness and access to these professional careers" (p. 24). In a similar vein, California Senate Bill 1, the Road Repair and Accountability Act of 2017, allocated funding to transportation-related workforce education, training, and development. That is how the current project is supported. The focus is on supporting participants' awareness of transportation-related careers and industry competencies (e.g., the DOL competency model for traffic operations, transportation planning etc.) (SETWC, 2019).

Unfortunately, not all youth have the same opportunities to be exposed to a wide diversity of career opportunities or to engage in high quality learning experiences and develop academic self-efficacy, pursue technical careers, and have a positive impact as citizens. However, the academic and civic empowerment gap can be closed by providing underserved students with interactive and authentic civic experiences (CIRCLE, 2013; Hart & Wandeler, 2018; Levinson, 2012; Rubin & Hayes, 2010). Further, our previous examination of a similar project, the *Fresno State Transportation Challenge,* found that exposure to transportation-related issues, and interaction with transportation professionals, increased students' awareness of career opportunities and career-related efficacy beliefs (Wandeler, Hart & Mercado, 2019). Specifically, students reported that they learned about the transportation engineering profession and developed their interest to pursue higher education opportunities. Further, the pedagogical approaches of action civics, agile learning, and design thinking, which framed the *Fresno State Transportation Challenge*, were also found to be influential on K–8 students' learning. Students reported that they had a chance to be creative and work on meaningful projects to improve their community, learned how to collaborate better with a team, developed their critical thinking, and overcame challenges when working on the project.

Project Goal

This project aims to provide underserved minority students from rural areas with opportunities to examine transportation careers, and engage in community transformation through high quality educational experiences. The Central Valley Transportation Challenge will provide opportunities for K–12 students and teachers to collaborate with transportation and engineering professionals from university and industry sectors in conducting civic action projects on transportation issues intended to improve their communities. The project:

- Aligns with the California State University Transportation Consortium (CSUTC) targeted need to attract and retain women and minorities in the transportation workforce.

- Aligns with the CSUTC objective of creating safer communities, increased access to transit, and greater opportunities for use of active transportation modes (i.e., biking and walking) through complete streets and innovative land use planning, so that people of all abilities and socioeconomic levels enjoy the same opportunities for learning, living, labor, and leisure.

Project Alignment with SB 1 Goals and Consortium Research Objectives

Building on the knowledge gained from previous research, the current project focused on the development and implementation of the Central Valley Transportation Challenge (CVTC). This project is aligned with the SB 1 Goals and Consortium Research Objectives: the CSUTC targeted need to attract and retain women and minorities in the transportation workforce, and the CSUTC objective of creating safer communities, increased access to transit, and greater opportunities for use of active transportation modes (i.e., biking and walking) through complete streets and innovative land use planning, so that people of all abilities and socioeconomic levels enjoy the same opportunities for learning, living, labor, and leisure.

This project aimed to support the development of a more diverse transportation workforce, and to attract and retain women and minorities in the transportation workforce. The project attempted to achieve this by providing opportunities for K–12 underserved minority students, particularly those from rural areas, to examine transportation careers and interact with transportation professionals. Further, this project also aimed to support efforts to create safer communities, increased access to transit, and greater opportunities for use of active transportation modes as the K–12 students collaborated with transportation and engineering professionals to conduct civic action projects on transportation issues intended to improve their communities.

In the following sections of this report, we present an overview of the objectives of this project and an overview of the design of the CVTC. Next, we provide a description of how each objective was met. Last, we discuss the overall knowledge gained from this project and recommendations for program implementation and policy.

Overview of Methodology and Approach

The project goal will be accomplished through three main objectives that intersect within the CVTC program. First, the project will support K–12 teachers' understanding and implementation of the CVTC programs. The CVTC program will create opportunities for students to explore transportation topics in meaningful and authentic contexts. Second, the project will connect K–12 students with university faculty and students, and transportation professionals, through the CVTC program. These interactions will deepen students' knowledge as they explore transportation topics.

Third, the project will employ technology to create a shared repository of transportation-related lesson plans and lesson sequences. This repository will also make it easy to contact the authors of the lesson plans and experts. The database will facilitate participating teachers' access to resources for use during implementation of the CVTC program; it will also serve as an accessible resource for all subsequent educators to engage their students in examining transportation career opportunities in meaningful and authentic ways.

2. Methods

Participants: Cases

The recruitment of teachers and community advisors/mentors was a collaborative effort between project directors and project external advisors. Recruitment of K–12 teachers took place during the summer (June–August). Jon Corippo, representative of Computer-Using Educators (CUE) Central Valley Affiliate, assisted in recruiting rural teachers from this network of over 20,000 educators. The recruitment of transportation professionals began in the summer (June–August) and continued throughout the project, based on students' transportation topics. Nikolaus Carcha, representative of American Civil Society of Engineers (ASCE) Central Valley Region, assisted in recruiting transportation professionals from this network of 58 members. Recruitment of university faculty and students occurred prior to each academic semester since teaching and course assignments changed during these periods. Project directors recruited university faculty and students through the College of Engineering and College of Education at Fresno State.

Table 1. Overview of Cases

Case	*Grade levels*	*Teacher*	*Teacher experience level*	*Gender*	*Number of Students*	*District*	*Type of District*
Case number 1	K–2	Alejandra	Experienced teacher	Female	12	Visalia	Rural
Case number 2	3–4	Gloria	Experienced teacher	Female	18	Visalia	Rural
Case number 3	6	Destiny	All in person Student teacher with mentor teacher	Female	12	Madera	Rural
Case number 3	6	Roxanne	All in person Student teacher with mentor teacher	Female	12	Madera	Rural
Case number 4	6	Taylor	Experienced teacher Hybrid flex	Female	25	Madera	Rural
Case number 5	9–12	Sean	Experienced teacher	Male	7	Fresno	Urban

The demographics of the districts we worked with are documented in Table 1. The students who participated in the project came from two rural, and one urban, districts in the Central Valley in California (see Table 2). Visalia has a substantial percentage of underserved students, Madera and Fresno have very high levels of underserved students and the three districts have between 14.4–

25.8 percent English learners. Thus, we were able to reach the student population that we initially targeted with this project. Fresno Unified is the third largest district in the State of California and is uniquely positioned within the Central Valley to serve as a regional hub for the rural regions. Madera is an example of the rural communities in the northern Central Valley, while Visalia exemplifies the rural communities in the southern Central Valley.

Table 2. Demographics of the Participating Districts in 2020-21 (Ed-Data.org)

District	Cumulative Enrollment Number of students	Indicator for Underserved students Unduplicated Pupil Count of Free/Reduced-Price Meals, English Learners & Foster Youth	English learner percentage	Type of District
Visalia	30,104	68.54%	14.4 %	Rural
Madera	20,908	90.51%	25.8 %	Rural
Fresno	72,419	87.35%	18.0%	Urban (in rural environment)

Study Design and Data

The authors' research design consisted of an *illustrative case study* approach. In this case, the collaboration projects with the teachers are described in more detail. The data sources are the work and artifacts of the students, such as research, discussions, drafts, and final presentations. Also included are notes from the preparation of sessions, notes from the actual sessions with the students, and notes from the reflection sessions of the university faculty with the K–12 teachers, California State University (CSU) transportation engineering students, and education students.

Overview of the CVTC Program

The CVTC leveraged expertise gained through the *Fresno State Transportation Challenge* to make the resources of the Fresno State Transportation Institute more accessible to rural students.

The CVTC exposed students to a transportation-related challenge (e.g., how might we get more students to bike to school? How can we make walking to school safer?). This challenge frames the interaction between the K–12 students, the university engineering students and faculty who support the K–12 students and their teachers in their work on the projects. The culminating outcome was ideally a community showcase, where students present their work to the public.

Because of COVID, the showcase was adjusted, and it resulted in a virtual presentation between different student teams.

This program is framed by service-learning and action civics pedagogies. The goal is for students to work on a project that is meaningful to them and to their community. We used a process inspired by design thinking and engineering thinking to guide students through a different process phase in developing meaningful projects addressing transportation-related issues (see Table 3). Typically, the start involved a phase zero period where students learned more about transportation, various modes of transportation, and transportation careers. Phase zero sets the transportation-related context. In phase one, students identified a topic or issue of concern, grouped together around similar interests, and then conducted initial research on the identified topics (e.g., how do students get to school? How could we get more students to ride bikes?). The students identified the problem and presented the challenges (e.g., How many students walk to school? Conduct a walkability audit. Conduct a safety audit.). In the second phase, students imagine, design, and create solutions. This phase also allowed room for student teams to create a system map of stakeholders, gather resources and collaborate with community advisors/mentors (e.g., university faculty and students, professional civil engineers, government officials) to engage in deeper research of the selected issue and determine potential solutions, and develop an action plan for implementation. In phase three, student teams collaborated with community advisors/mentors to create an action plan. In phase four, they implemented the action and planned and tested out their ideas. In phase five, the students continually reflected on the efficacy, and evaluate the progress of that plan, making adjustments and redesigning as necessary. Finally, in phase six, students constructed presentations to share at a showcase event informing the public about their actions.

It is important to note that this design thinking process is a structure that is also open to adjustment by the teachers and practitioners. The case studies will show different varieties of this basic structure. This further enables the CVTC to be agile, and it has proven to be a highly flexible and adaptive model, with regard to the technology and teachers' experience and pedagogical expertise.

Alignment of the CVTC Program with Education Standards

A typical obstacle for bringing transportation-related education to schools is cooperation and buy-in from the administrators and/or teachers. Feedback from our project advisors emphasized that an alignment with teaching standards is very helpful. Thus, we created Table 3, which makes it very easy for educators to see how a project relates to the other work they do with students, and opens up the opportunity to potentially replace some of the other content that students engage with.

This overview of the alignment with the standards also helps in conversations with educational leaders, so that they can better understand how this learning experience fits in the overall curricular picture and fits in with their other strategic objectives. The Alignment of the CVTC Program with the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013), Common Core

State Standards for English Language Arts & Literacy in History/Social Studies (CCSS) (Common Core State Standards Initiative, 2010), and California Career Technical Education Model Education Standards for Transportation (CDE, 2017) is described in Table 3.

The different project phases of the transportation challenge reflect the NGSS ETS 1-1, 1-2, 1-3 and 1-4. These are the standards related to engineering design. A detailed overview of the standards can be found under Table X. The different project phases of the transportation challenge also map nicely onto a broad spectrum of the CCSS literacy standards. There was also substantial alignment with the CTE transportation anchor standards, the NGSS Engineering Design Standards overview, and the CCSS overview.

Table 3. NGSS, CCSS and CTE Standards by Transportation Challenge Academic Scope and Sequence

Project Phase	NGSS	CCSS Literacy	CTE - Transportation Anchor Standards
1: ASK What is the problem? How have others approached it? Developing & planning inquiries; Gathering & evaluating sources	ETS 1-1	CCRA.R.1-3; CCRA.R.7-9 CCRA.W.1-2; CCRA.W.4-9 CCRA.SL.1-2; CCRA.SL. 6	4.5 Research past, present, and projected technological advances as they impact a particular pathway.
2: IMAGINE What are some ideas? Developing claims using evidence	ETS 1-1	CCRA.R.1-3; CCRA.R.7-9 CCRA.W.1-2; CCRA.W.4-9 CCRA.SL.4-5; CCRA.SL. 6	5.1 Identify and ask significant questions that clarify various points of view to solve problems.
3: PLAN What's your plan? What will you need? Designing before creating	ETS 1-2	CCRA.W.7-9 CCRA.SL.1-2; CCRA.SL. 6	
4: CREATE Does it work? Testing out models	ETS 1-2 ETS 1-3 ETS 1-4	CCRA.W.7-9 CCRA.SL.1-6	5.4 Interpret information and draw conclusions, based on the best analysis, to make informed decisions
5: EVALUATE/REDESIGN What could be improved? Learning by trying; Communicating & critiquing	ETS 1-2 ETS 1-3 ETS 1-4	CCRA.W.7-9 CCRA.SL.1-6	5.4 Interpret information and draw conclusions, based on the best analysis, to make informed decisions
6: SHARE SOLUTION How can you share this with others? Disseminating Ideas	ETS 1-4	CCRA.W.6 CCRA.SL.4-6	7.5 Apply high-quality techniques to product or presentation design and development.

Table 4. NGSS – Engineering Design Standards Overview

Standard	Description of the Standard
MS-ETS1-1.	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2.	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3.	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4.	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Table 5. CCSS – Common Core Social Science Standards Overview

Standard	Description of the Standard
MS-ETS1-1.	Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2.	Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3.	Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4.	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

The CVTC in Times of the COVID-19 Pandemic

The CVTC was supposed to take place in-person in Fall 2020 and Spring 2021. However, because of COVID-19, the project had to be adjusted, and both the process and goals of the project were adapted. The main challenges we dealt with during COVID-19 were that we moved to the online space, which in of itself, was not a considerable issue. The bigger challenge was that schools and teachers were overwhelmed with changing demands, and projects such as ours were the first ones to be canceled. Once we recruited another batch of teachers, the main school district we were collaborating with announced that they would return to in-person schooling, which again lead to a shift in priorities. Nevertheless, we managed to conduct quality projects in three different school districts.

3. Results

The project goal will be accomplished through three main intersecting objectives within the CVTC program: the implementation of CVTC in K–12 classrooms; exposing students to transportation professionals; and the online repository. First, the project will support K–12 teachers' understanding and implementation of the CVTC program which will create opportunities for students to explore transportation topics in meaningful and authentic contexts. Second, the project will connect K–12 students with university faculty and students, and transportation professionals through the CVTC program. These interactions will deepen students' knowledge as they engage in exploring transportation topics. Third, the project will employ technology to create a shared repository of transportation-related content to form an online hub. This database will facilitate participating teachers' access to resources to use during implementation of the CVTC program. it will also serve as an accessible resource for all educators to engage their students in examining transportation career opportunities.

The results for the first two objectives (implementation of CVTC and connection to university faculty, students, and transportation professionals) will be discussed in five case studies. The results of the third objective will be a description of the repository of transportation-related content.

The CVTC: An Agile Pedagogy

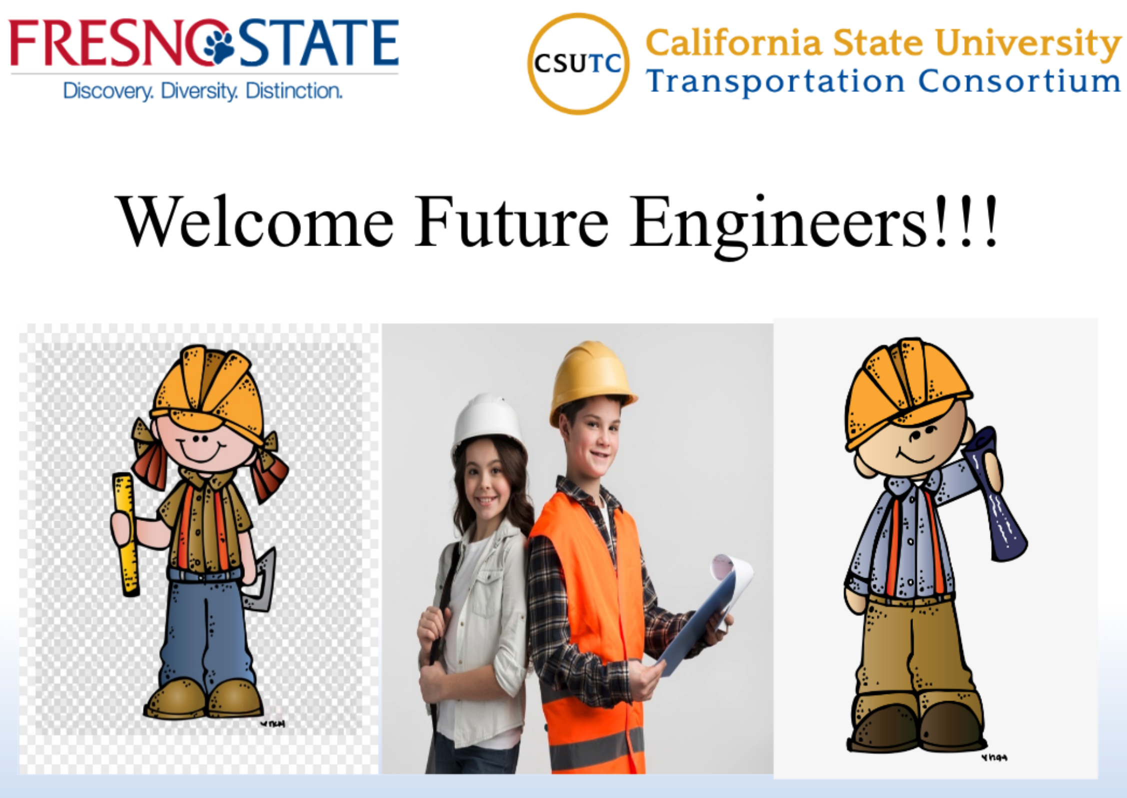
The CVTC has a generic structure with the project phases documented in Table 3. Depending on the teacher, the students, and the content, the structure can be adapted. A key feature of the program is collaborative implementation revision through teacher/faculty/engineer discussions. Typically, after each lesson there was a reflection session, and we would adapt the process depending on what we learned and the feedback from students.

Case 1 Alejandra: Working with Young Students

Teacher A (TA) taught at a rural K–8 charter school framed around project-based learning and the concept of multi-age classrooms, also referred to as mixed-age or mixed-grade classrooms, where students work and learn together across more than one grade level. TA taught a K–2 multi-age classroom through virtual distance learning due to COVID-19. We highlight this case to illustrate how the Challenge model was easily adjusted to be more developmentally appropriate for very young students. We also present this case to illustrate how collaboration among teachers and program staff played a key role in facilitating program implementation as we worked to create structures that scaffolded the process for the young students.

As noted in the general session outline above (Table 3), the first session aims to provide students an overview of transportation, various transportation-related careers, and initiate the process of thinking about how transportation impacts their lives (Fig. 1). For the engineers, working with children was a unique experience, and working with such young children especially so. During the session, there was much confusion from the kids about the engineering and transportation concepts presented. At the end of the session, the program staff and teachers met to debrief and make adjustments. TA's experience with project-based learning and pedagogical experience was an important part in reshaping the process of implementation.

Figure 1. Activating Students' Prior Knowledge and Interest in Transportation Careers



Through this dialogue, the engineers were able to draw on the teacher's expertise to develop a more scaffolded approach to presenting concepts and vocabulary terms. The scaffolding moved from broad brainstorming of transportation modes to a structured examination of one mode at a time in a series of subsequent sessions. Each broad mode of transportation—land, water, air—was covered in two sessions each. In session one, the engineers provided examples of vehicles for the mode of the day (i.e., land, water, air), and how people use these different vehicles in commercial, industrial, and personal contexts. Between sessions, one and two the children used notebooks, pictures, and video to capture examples of the transportation mode in their everyday lives. In session two, the engineers guided students to build a model of the mode of the day. To layer in vocabulary and engineering concepts throughout the building process, the engineers identified and labeled basic mechanical parts of the vehicle. The students then tested out their models, documented and recorded observations, and then shared them. The design-and-refine process of engineering was developed as students tweaked, tested, observed, and reported on their findings.

In the general design of the Challenge, after the overview of transportation modes, students typically move to identifying and examining transportation-related issues in their communities. These investigations are usually student-led and teacher-facilitated, with students ultimately selecting the issue of interest. However, these next phases also required developmentally appropriate adjustments for the younger children, and these adjustments were also supported through collaborative discussions among teachers and program staff members. Drawing on her pedagogical expertise and knowledge of the children, TA believed that her younger students would need more controlled and structured inquiry, and recommended that the engineers guide the students to examine issues of pollution related to transportation. TA identified this pathway based on previous conversations with the children about family purchases of electric vehicles and the air quality of the region. Following TA's suggestions, the engineers designed instructional materials and led sessions that guided the students through examining the causes and effects of various forms of pollution (Fig. 2) as well as examples of vehicles engineers were designing to address these issues (Fig. 3). Although the investigation phase was guided by the engineers, the children led the design of their own pollution-reducing vehicles. During these phases, engineers met with small groups of students via Zoom to discuss students' drawings, the design features of the vehicles, and how the design addressed particular forms of pollution (Fig. 4). Ultimately, these young students shared their vehicle designs during a class presentation.

Figure 2. Examining the Causes and Effects of Various forms of Pollution

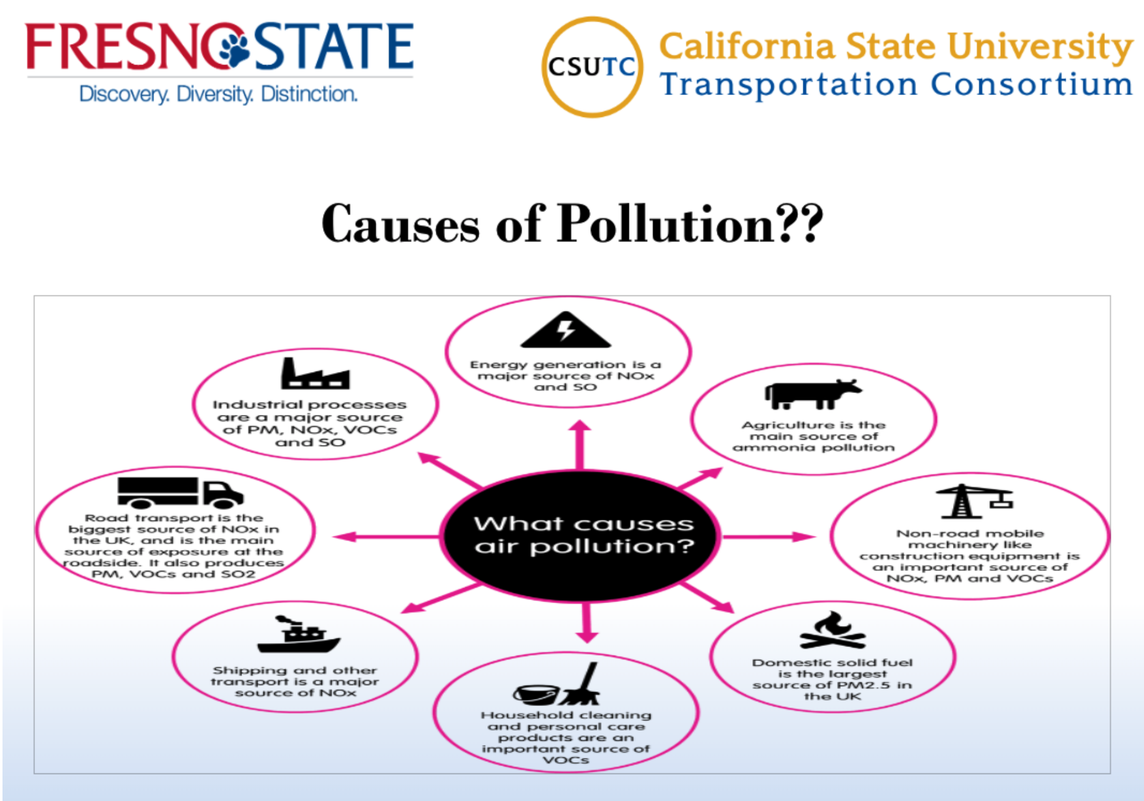
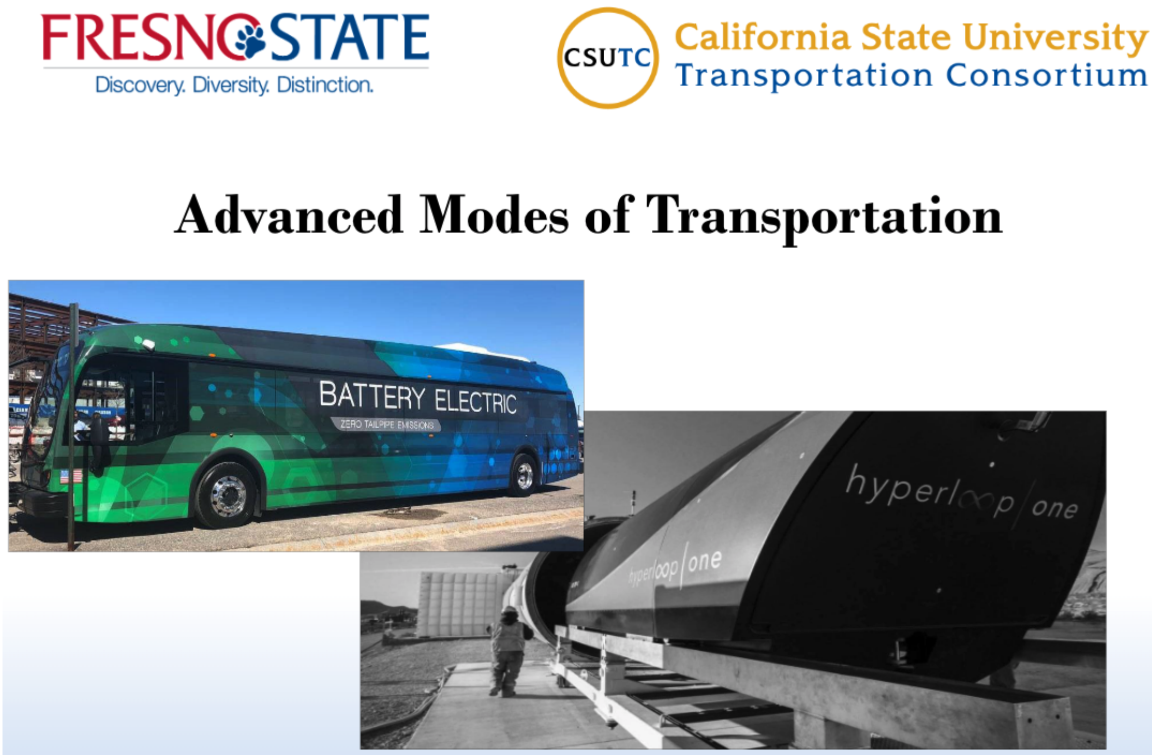
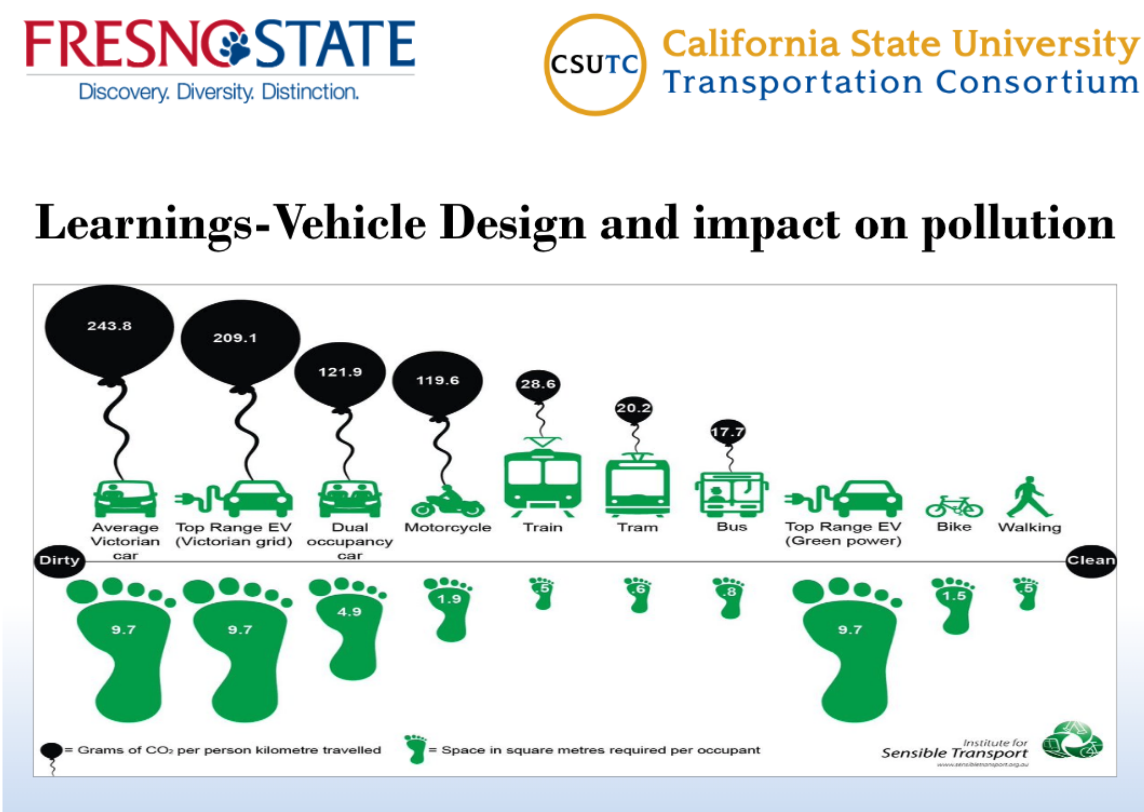


Figure 3. Examining more Sustainable and Environmentally Friendly Modes of Transportation



The structure of the Transportation Challenge is organized as to introduce students to the design-and-refine process of engineering in the first few sessions, and then guide students through the application of this thinking process as they work to design their own unique product. However, as this case illustrates, younger students require much more general knowledge about engineers and the work they do. Once this knowledge is developed, younger students will need multiple guided experiences examining the complex thinking associated with the design process.

Figure 4. The Impact of Different Designs and Modes of Transportation on Pollution



Case 2 Gloria – Working with young students and Technology in a Remote Setting

Teacher B (an experienced teacher, henceforth TB) taught at the same rural K–8 charter school as TA. So, similarly, in this case learning was project-based, and involved the concept of multi-age classrooms, also referred to as mixed age or mixed grade classrooms, where students work and learn together across more than one grade level. These were third and fourth grade students. The setting in this case was fully remote. The students were at home and the technology they had access to included tablets. The teacher, university faculty, and university students also joined remotely. The teacher was the virtual host and thus managed access to the main room and the breakout rooms.

This case illustrates how collaboration among teachers and program staff leverages everyone's strengths and leads to an enriched experience for the students. The teacher had extraordinary technology skills and a precise understanding of the technology usage skills of the students. The typical form of collaboration with the teacher involved a meeting before each session between the K–12 teacher, university faculty, and university students. The teacher's knowledge of technology and knowledge of the students' technology usage skills was of central importance. The university students contributed transportation content expertise, and the university faculty provided the core pedagogical structure of the design thinking process for the challenge as well as employed agile pedagogy. Table 6 provides an overview of the schedule, which was spread out over four weeks, with two sessions per week. To provide a more granular view of the content and learning activities within the sessions, here are more details from the actual sessions.

Because the students were younger and at home, there was a bit of a shift, and the instruction was more scaffolded.

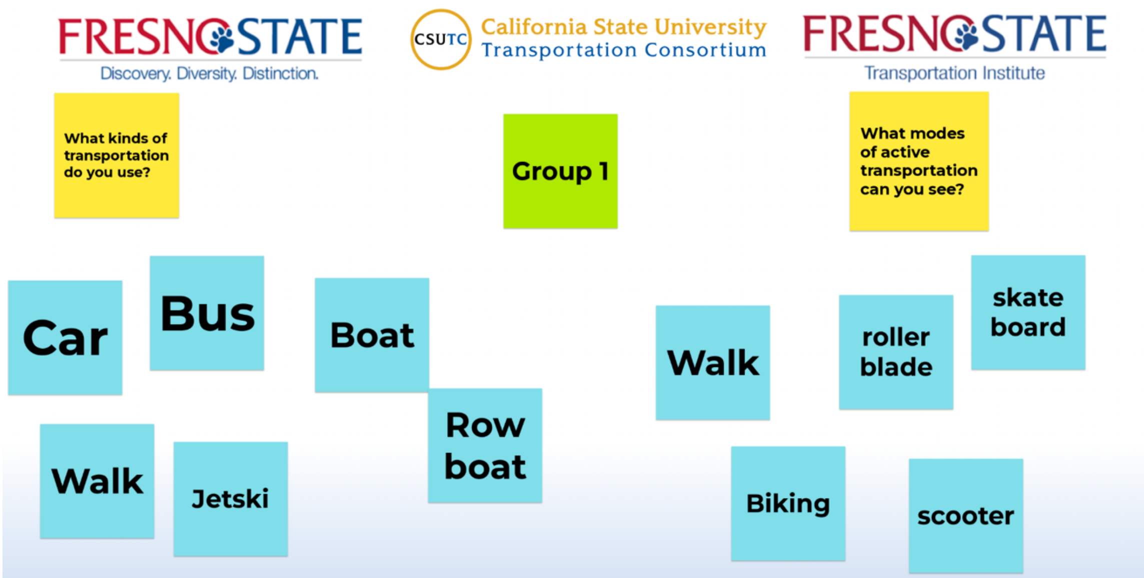
In another example of the use of technology, the teacher also created a Flipgrid, where students could record questions for the university students and transportation experts. This allowed them to communicate in an asynchronous manner.

Table 6. Gloria's Sample Schedule

Session	Activity
Session 1	Engineers present an overview of various modes of transportation.
Session 2	Students identify their school and house on Google Maps, and then identify different modes of transportation for getting to school.
Session 3	Students focus on their own ways of getting to school.
Session 4	Engineers explore what safe and unsafe bike lanes look like with the students.
Session 5	Students do a bike safety audit of their way to school.
Session 6	Students do a bike safety audit of the surroundings of their school.
Session 7	Students design a model to improve the surroundings of their school in regards to bike safety.
Session 8	Students prepare a showcase of their school in the form of a video.

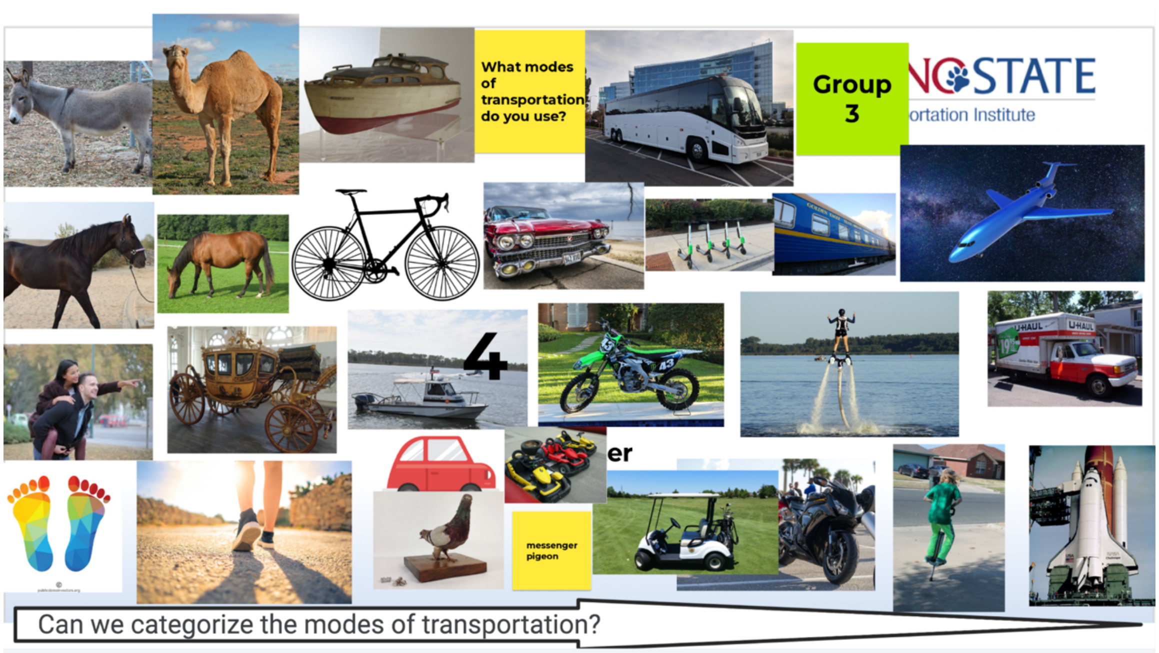
During the first session the aim was to assess the students' existing knowledge about transportation, various transportation-related careers, and initiating the process of thinking about how transportation impacts their lives. Fig. 5 is an example of activating students' prior knowledge, and getting them interested in the topic by connecting them with what they already know. The students were also able to ask the transportation experts (in this case, the university students) questions.

Figure 5. Activating Students' Prior Knowledge about Transportation



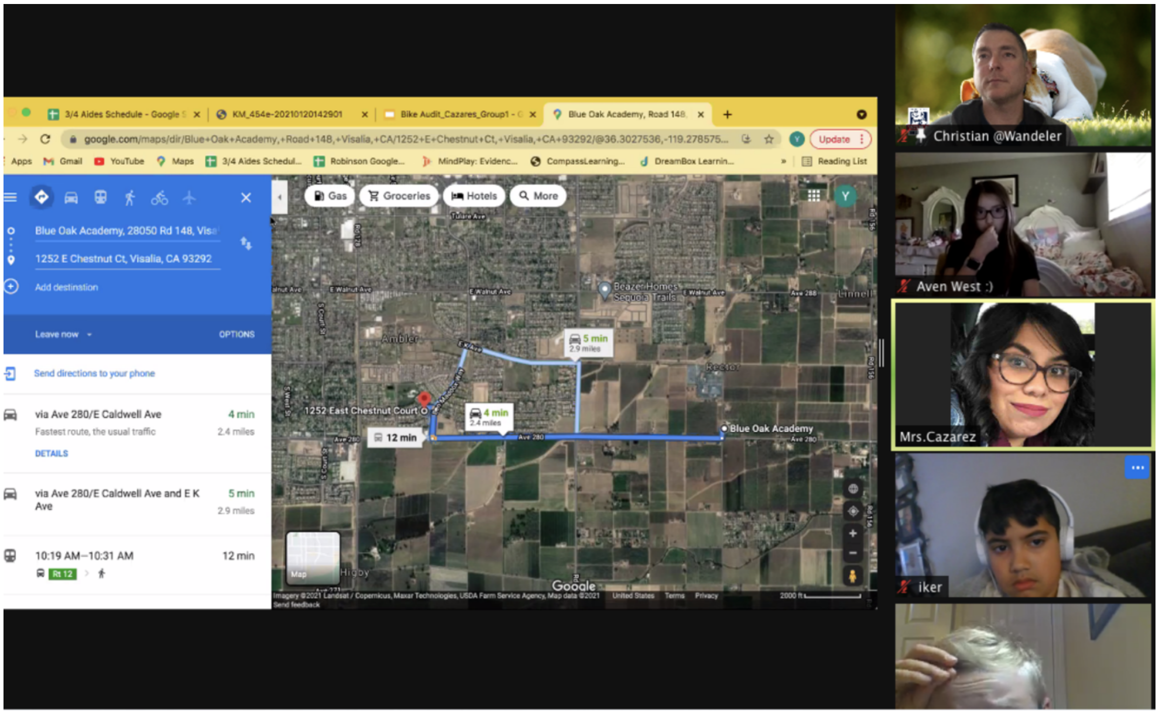
During this session the students also further researched online what different modes of transportation exist and how one might categorize them (e.g., historical timeline, use of various technologies, land vs. water vs. air.) (Fig 6).

Figure 6. Categorizing Modes of Transportation



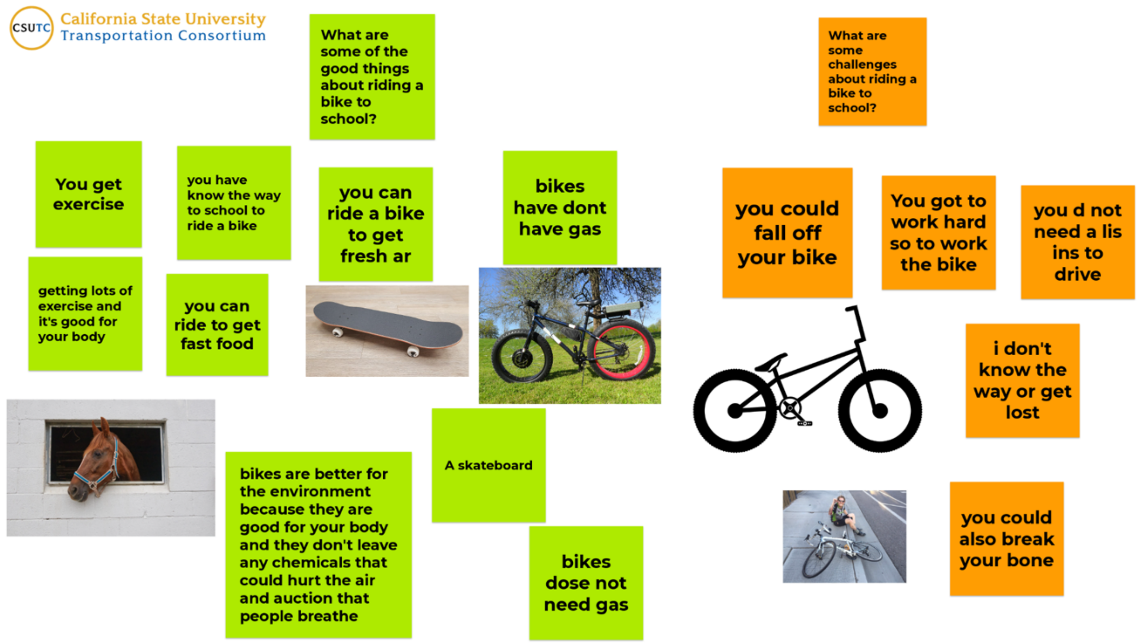
During the second session, the biking to school challenge was slowly introduced by having students use Google Maps to identify their school and their house, and identify different modes of transportation for getting to school (see Fig. 7)

Figure 7. Figuring out a Way to Bike from Home to School



During the third session, students focused on various ways of getting to school and what options were available to them personally and to their peers. Here the topic of transportation equity was woven in. For whom are public buses available? For whom is it close enough to walk? For whom is it close enough to bike? Do all the kids have bikes? Is it safe to walk? Is it safe to bike? What are good things about riding bikes? What are advantages and disadvantages of biking (Fig. 8)?

Figure 8. Advantages and Disadvantages of Biking to School



During the fourth session, students focused on the transportation equity perspective on the topic of the safety and particularly of biking. Because this was a country school, for many students it was quite a distance to walk, so biking seemed more realistic. The teachers, faculty, and university students were well aware of their own the biases about what is an appropriate or feasible time and distance to walk or bike to school. In small groups, the university students and students explored what safe and unsafe bike lanes look like (Fig. 9).

Figure 9. Learning to See Safe or Unsafe Biking Environments

During the fifth session, students focused on the transportation equity perspective of safety. Students completed a virtual bike safety audit (Figs. 10 and 11) of their way to school. During the sixth session, they focused on the surroundings of their school (Fig. 12). One can see that the school surroundings were very unsafe for bikes and for walking. Each student used Google Street View and collected screenshots of safe and unsafe bike lane situations to evaluate their way to school from a biking perspective. This involved a lot of collaboration. To illustrate, first, engineering students would explain safe bike lanes versus unsafe bike lanes. The students followed the way to school for one student and together discussed which parts were safe, unsafe, and why. After working through an example together, each student worked on their own, using their personal way to school.

Figure 10. Conducting a Virtual Bike to School Safety Audit

Figure 11. Learning to See Safe or Unsafe Biking Environments on the Way to School

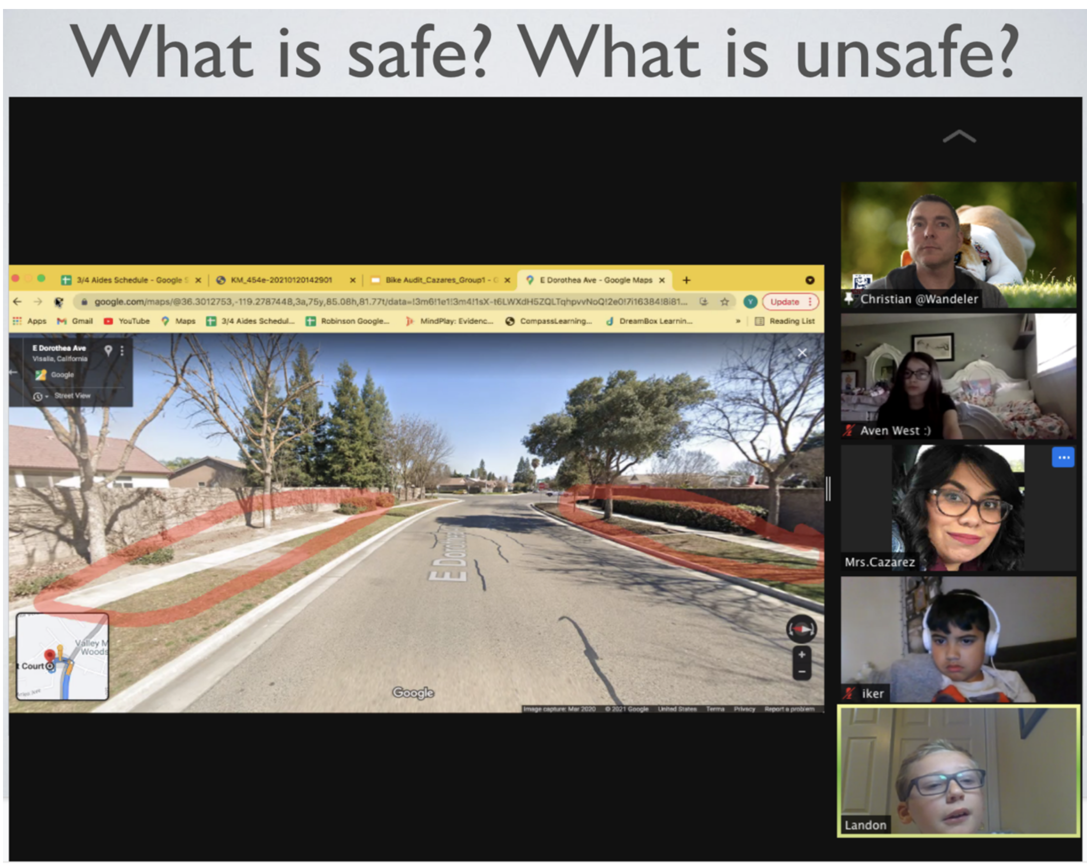
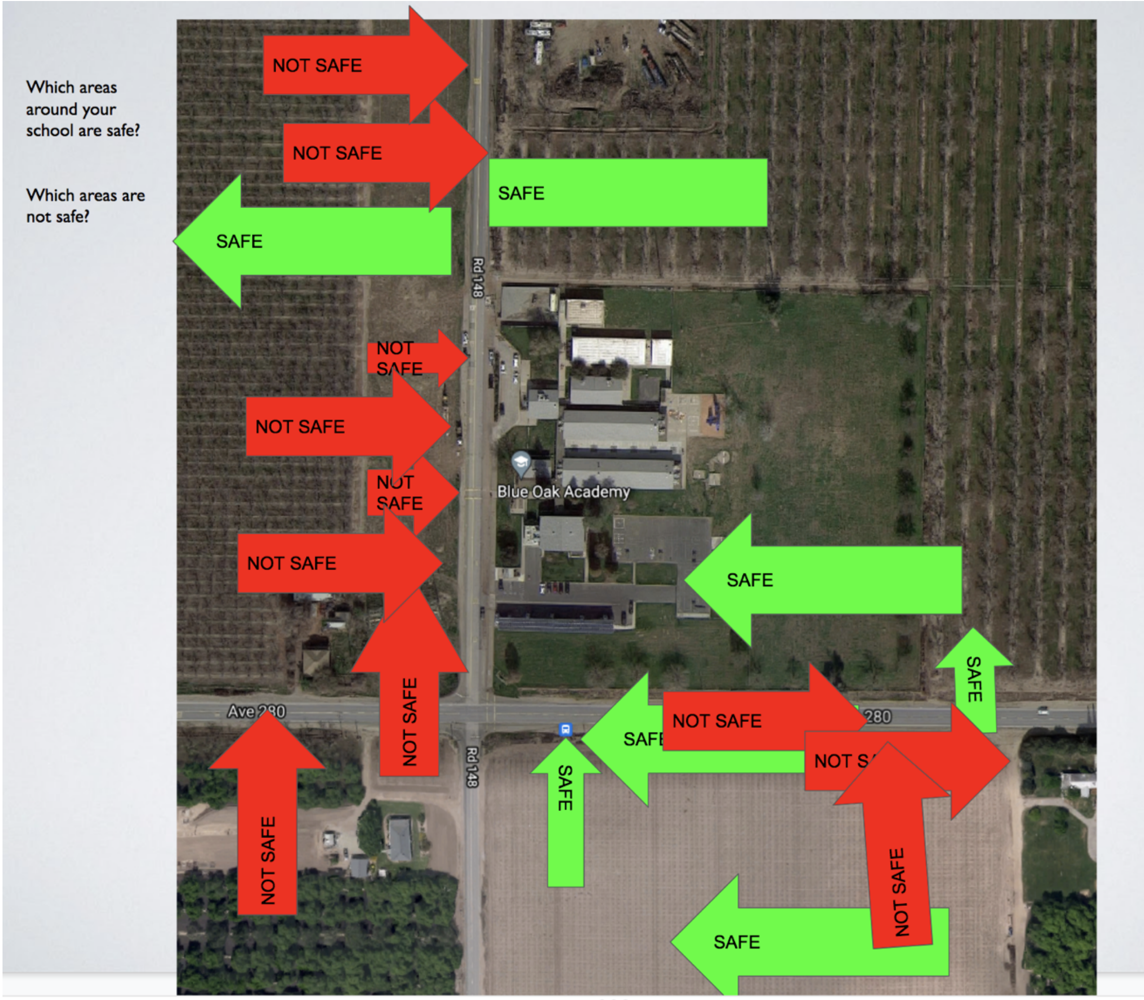


Figure 12. Learning to See Safe or Unsafe Biking Environments Around the School



During the seventh session, the students designed a model to improve the surroundings of their school for bike safety, using what they learned about safe biking and safe walking infrastructure. They creatively applied their knowledge to brainstorm how to make their community safer (Fig. 13) and then came up with a design for their school (Fig. 14). They improved their designs using feedback from the university students, university faculty, and their teacher. During the eighth session, the students prepared a presentation about their proposed redesign and presented it to the university faculty and students (Fig. 14).

Figure 13. Ideating How to Make Biking to School Safer

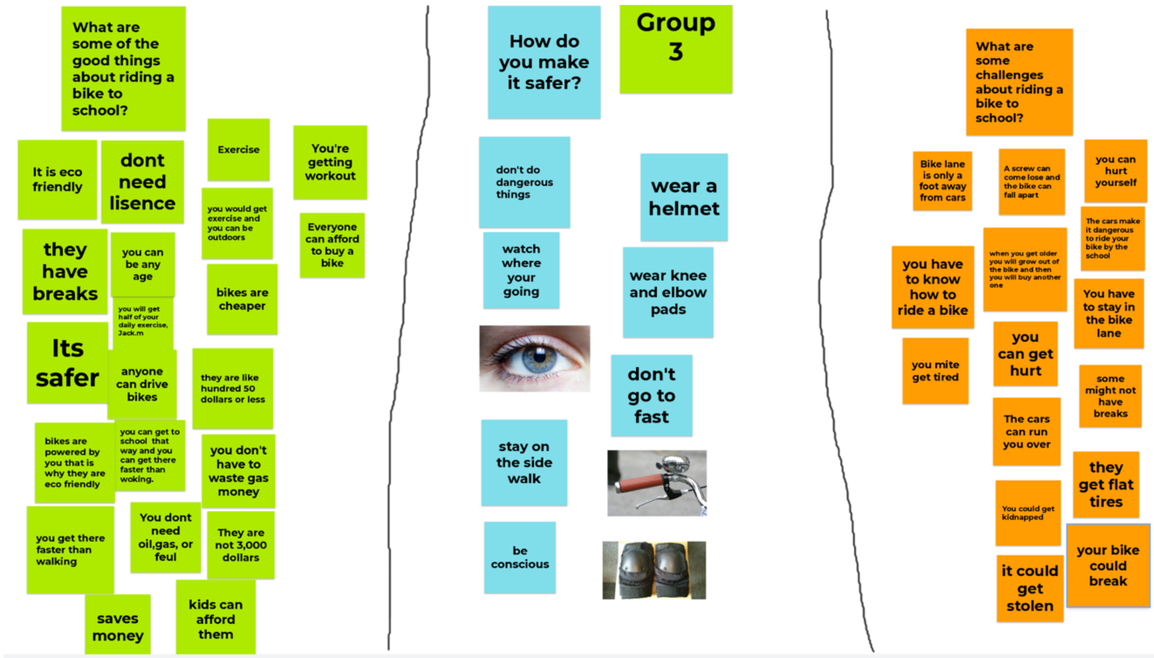
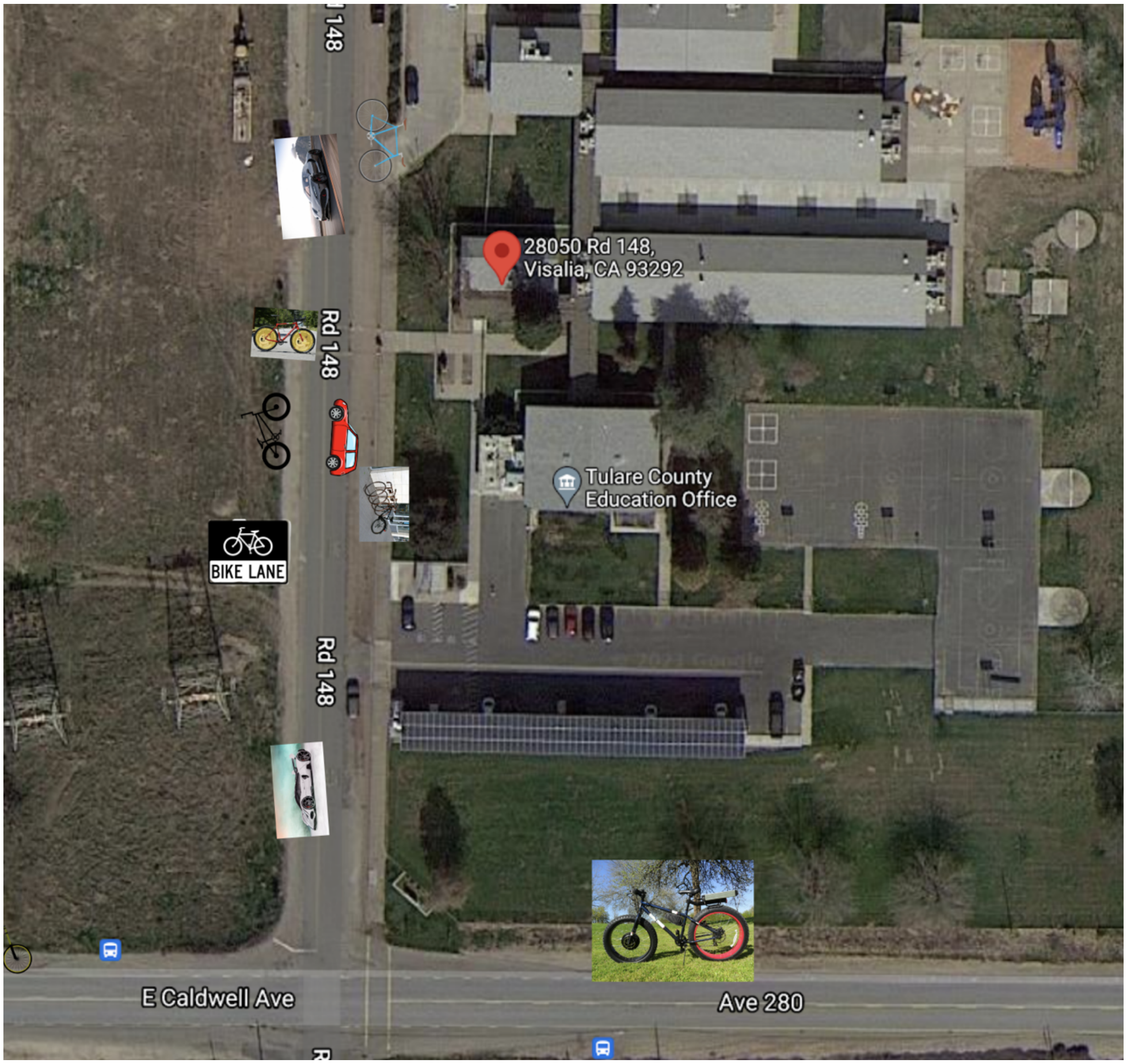


Figure 14. Proposed Changes Around the School to Create a Safe Biking Environment

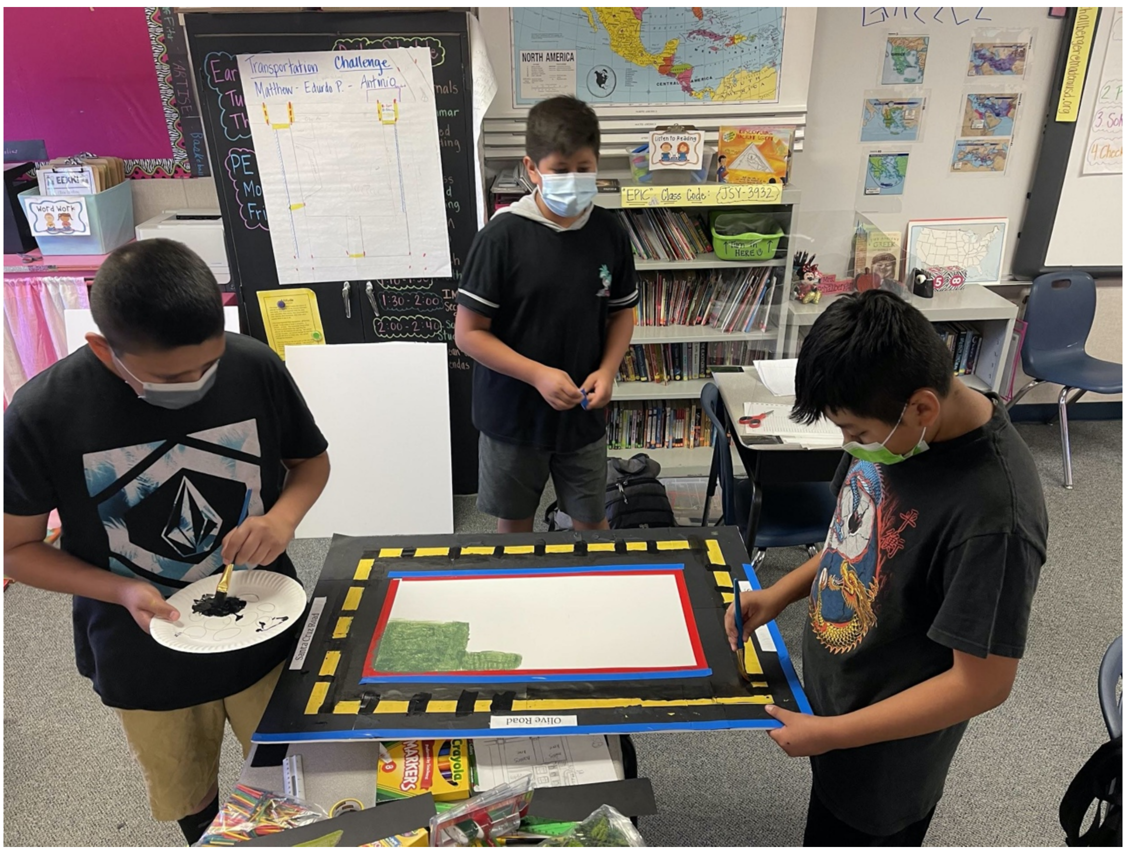


Case 3 Destyni and Roxanne: Mentoring and Experience with PBL

Teacher C (TC) & Teacher D (TD) were co-teaching sixth grade at an elementary school in a small town in the heart of an expansive agricultural region. TC is a veteran teacher and served as a mentor for TD, a student teacher from a local university. TC and TD co-taught at the school site, but due to COVID-19 protocols, their sixth grade class was split into two groups to facilitate social distancing. TC had extensive training in project-based learning and had frequently engaged students in community action and service-learning projects throughout her career. This case illustrates the flexibility in the structure of the Transportation Challenge to both facilitate a novice teacher's implementation of the program and to afford a veteran teacher opportunities to continue to grow and develop knowledge concerning transportation-related issues. Here is a video created by the Madera Unified District about the project: https://www.facebook.com/MaderaUnified/videos/833061597328620/

When program staff initially met with TC and TD to plan the procedures of the Challenge, TC immediately drew connections to her previous experience with service-learning: "Oh. These phases are just like when we do service-learning projects. Investigate, plan, act." Though TC was knowledgeable and confident in teaching through a project-based approach, she also noted her lack of expertise with transportation-related issues and engineering in general. It was during these initial planning sessions that the engineering students shared their expertise and provided a general overview of the content they would share with the children. Recognizing that the engineering students would be providing ongoing support to the children eased the concerns TC had about the content, "This makes me feel much better about the project. I can handle the steps and process. You guys handle the information. I'll be learning right with my students."

Figure 15. Students Developing a Model of their School



Similar to TC's stance that the Challenge would be a great learning opportunity to hone her knowledge of engineering practices and transportation issues, TD also viewed this experience as an opportunity to apply information learned during her teaching credential program. In particular, TD noted how the Challenge represented a unique instructional approach that she had learned about: "I'm excited to do this. This reminds me of project-based learning. We learned about it and had to design a unit with lesson plans, but I never taught it or saw it done in action."

Through this collaborative dialogue, in preparation for the Challenge, the teachers and engineering students were able to apply their individual sources of knowledge to shape the process and content for this unique context (e.g., Fig. 15). The culminating product from this collaboration was a series of lesson plans, which we outline below (Table 7).

Table 7. Lesson Plans for the Various Sessions

Date	Activity
Session 1	Engineers present an overview of engineering and major transportation issues engineers are working on/current technology (10-15 min).
Session 2	Engineers share more current technology (10 min).
Session 3	Engineers provide an overview of design and models (10-15 min).
Session 4 & 5	Engineers provide an overview of testing/documenting in the journal redesign process (10-15 min)
Session 6	Feedback is given to students.
Session 7	The showcase is prepared and the videos are presented.

We will describe these sessions and highlight the ways the teachers' expertise and the engineering students' expertise contributed to the students' learning experiences. Sessions 1 through 7 were framed around inquiry: How does my community use various modes of transportation?

The sequence was built around what they already know: project-based learning unit design, and children's literature. This resulted in lesson plans that framed the unit in children's literature related to engineering, and emphasized the importance of investigating transportation and transportation careers.

As noted in the general session outline earlier, the first session aims to provide students with an overview of transportation, various transportation-related careers, and initiates the process of thinking about how transportation impacts their lives.

The structure of the Transportation Challenge is organized to introduce students through the design-and-refine process of engineering in the first few sessions, and then guide students through the application of this thinking process as they work to design their own unique product. However, as this case illustrates, younger students require much more general knowledge about engineers and the work they do. Once this knowledge is developed, younger students will need multiple guided experiences examining the complex thinking associated with the design process.

This case highlights the flexibility of the model to allow teachers to build around what they already know and utilize resources such as children's literature or their project-based learning expertise to create an engaging and effective learning experience.

Figure 16. Students Designing Safety Improvements (in this case a green island as a buffer to protect the student pick-up zone)

Figure 17. Students Building Realistic 3D Models

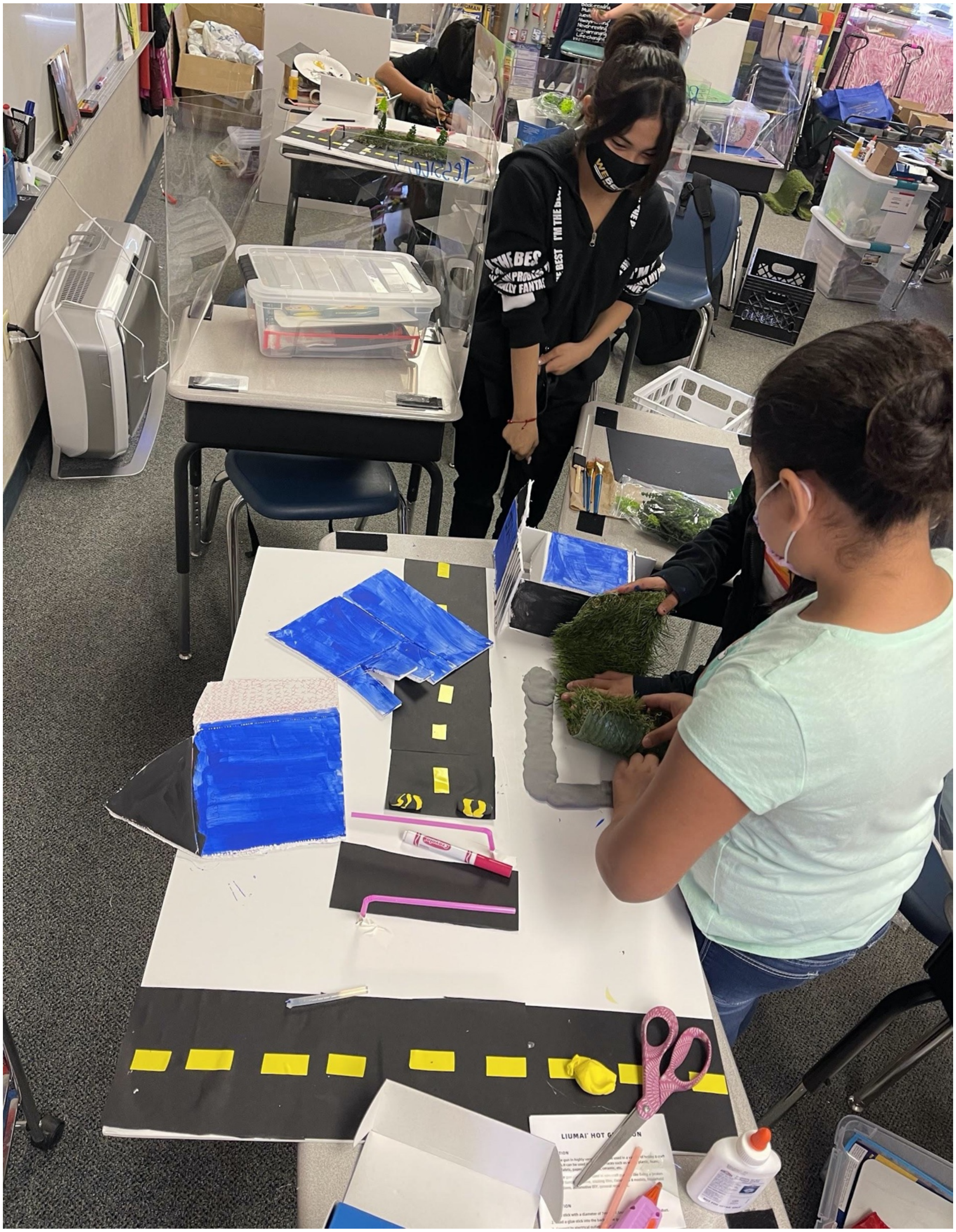


Figure 18. University Student Supporting Students in Mapping out their School

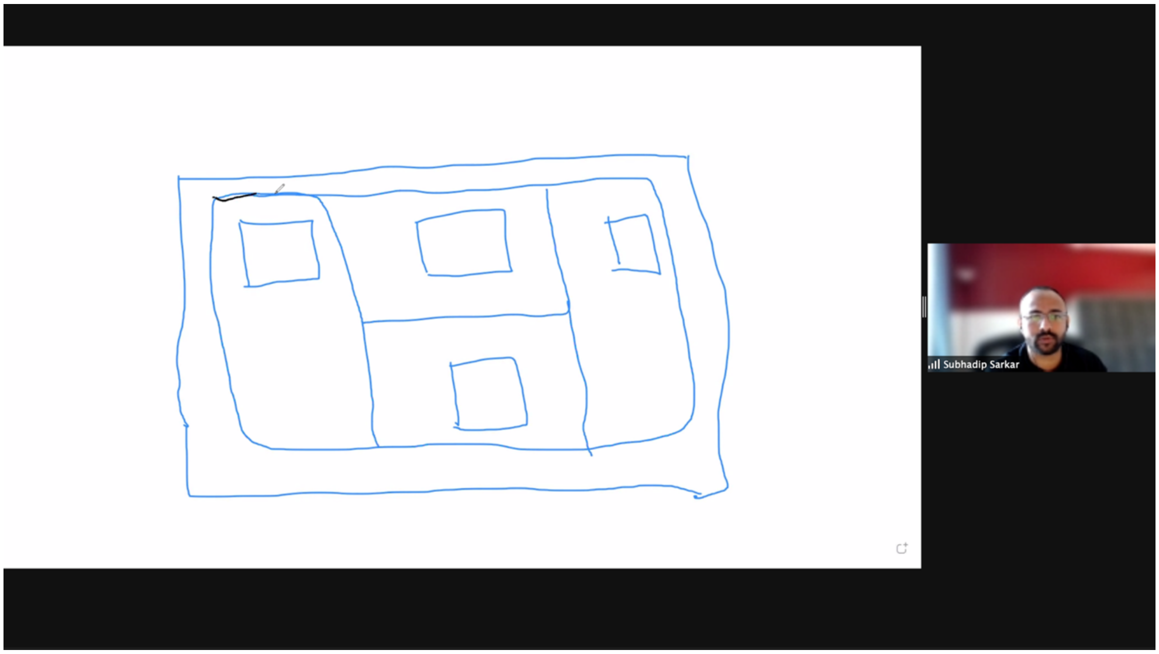
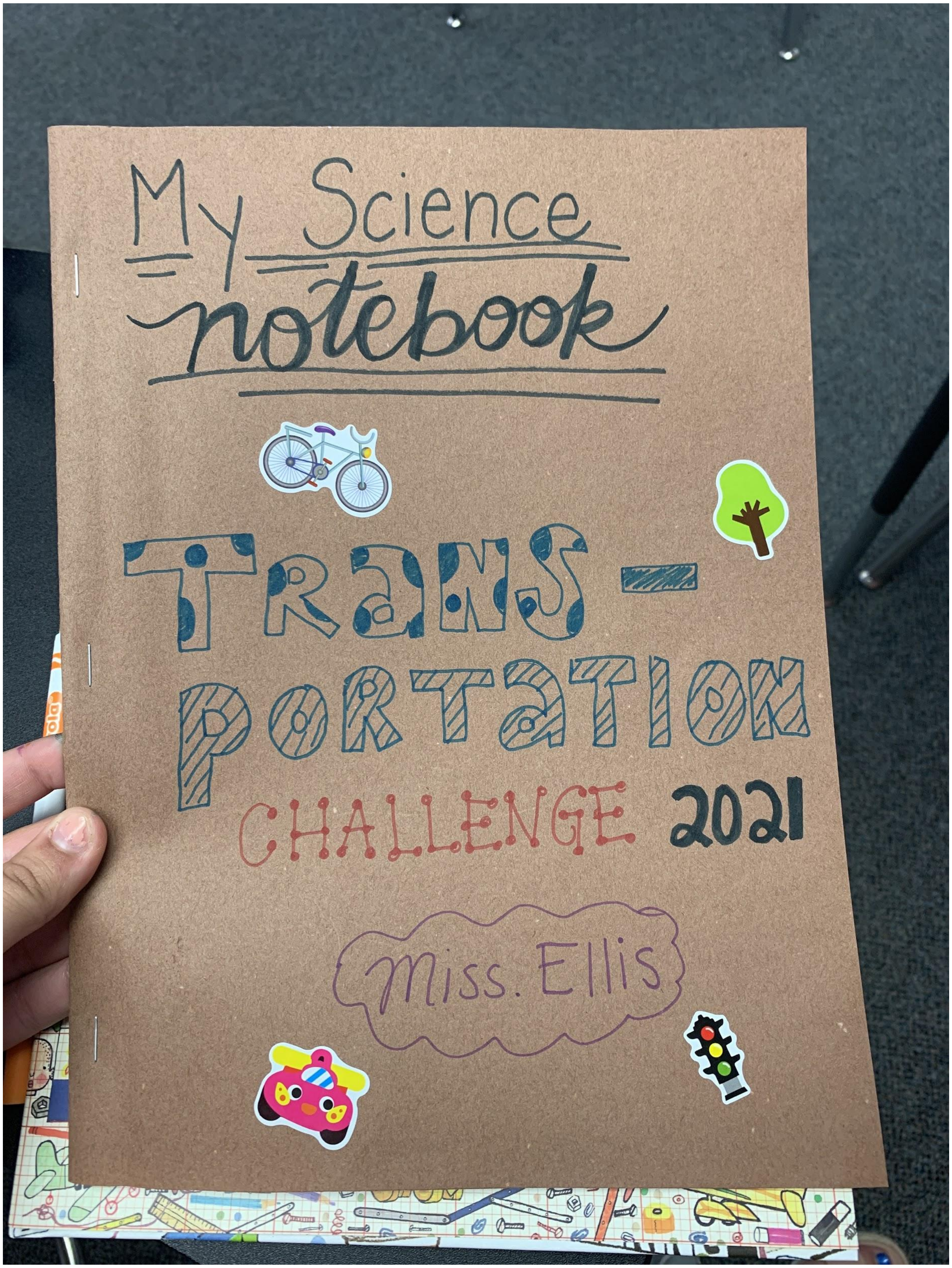


Figure 19. Science Notebook Used during the Transportation Challenge



Case 4 Taylor: PBL in a Hybrid Flex Context

Teacher E (TE) was familiar with PBL (like Teacher C) and was also teaching sixth grade at an elementary school in a small town in the heart of an expansive agricultural region. TE was a veteran teacher and was also serving as a mentor teacher for novice teachers. This teacher drew on the engineer's expertise, and leveraged the unique context of groups working together and collaborating in class, but then also incorporated virtual spaces and homes. Many of the students were at home, so the teacher delivered materials and resources to their homes.

Figs. 14 and 15 show a student in the classroom performing a demonstration of his prototype for an alternative form of transportation. The nature of the hybrid flex model is such that a part of his audience are students at home, and only a portion are with him in the classroom. A similar example showcasing the hybrid flex model is documented in Fig. 16 and shows a student that is at home sharing his experiment of developing an alternative substance to fill in potholes. Here, too, part of the audience is at home and the other portion is in the classroom. In this case, the student had more resources at home than at the school, because he used the kitchen oven to bake various substances and test their suitability for filling the holes in the mold. He had identified potholes in California's highways and freeways as a major opportunity to improve the life in his community. In Fig. 17, another example of student work, a solar-powered electric car is portrayed. This student did all the project work at home.

This hybrid flex model was a powerful example of how the transportation challenge can not only be brought to rural communities, but also to the homes of underserved students.

Table 7. Sample Schedule

Date	Activity
Session 1	Engineers present an overview of engineering and major transportation issues engineers are working on/current technology (10-15 min).
Session 2	Engineers share more current technology (10 min).
Session 3	Engineers provide an overview of design and models (10-15 min).
Session 4 & 5	Engineers provide an overview of testing/documenting in the journal redesign process (10-15 min).
Session 6	Feedback is given to students.
Session 7	The showcase is prepared and videos are presented.

Figure 20. Student Presenting his Prototype for an Alternative form of Transportation

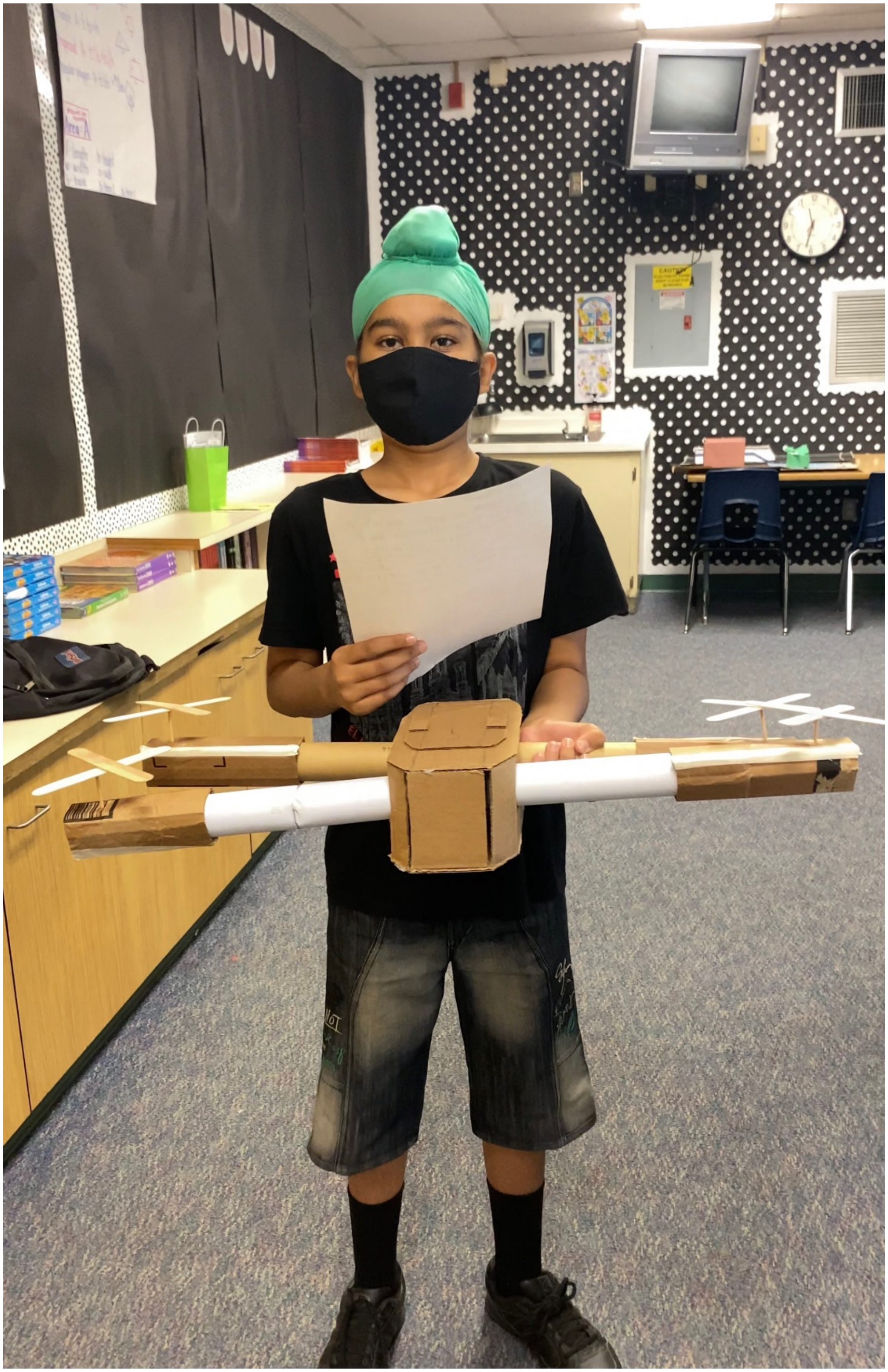


Figure 21. Student in the Classroom Presenting his Prototype for an Alternative form of Transportation to Students at Home and in the Classroom

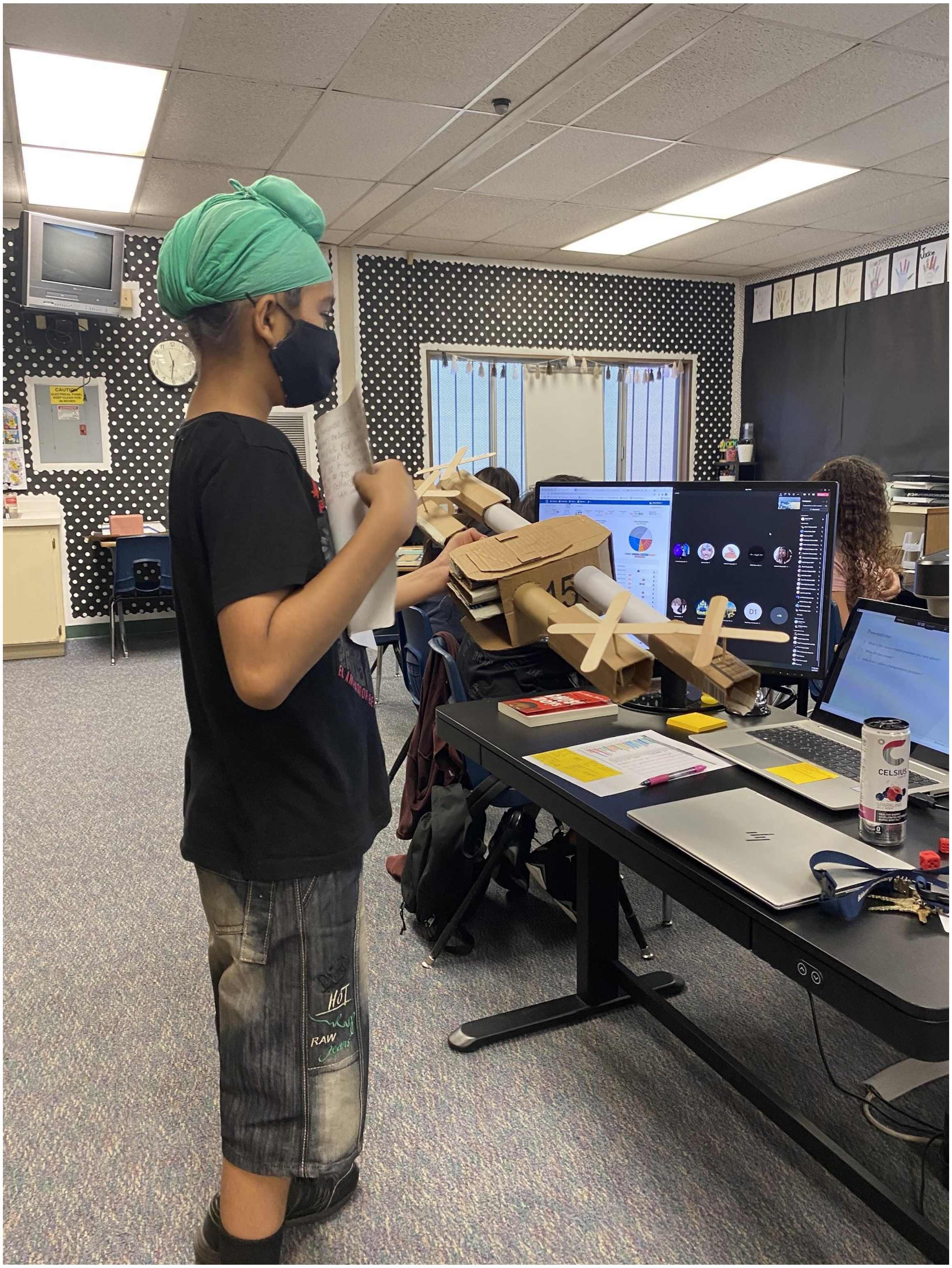


Figure 22. Student at Home Performing a Demonstration of his Experiment, Developing a Substance to Fill in Potholes, for Students at Home and in the Classroom

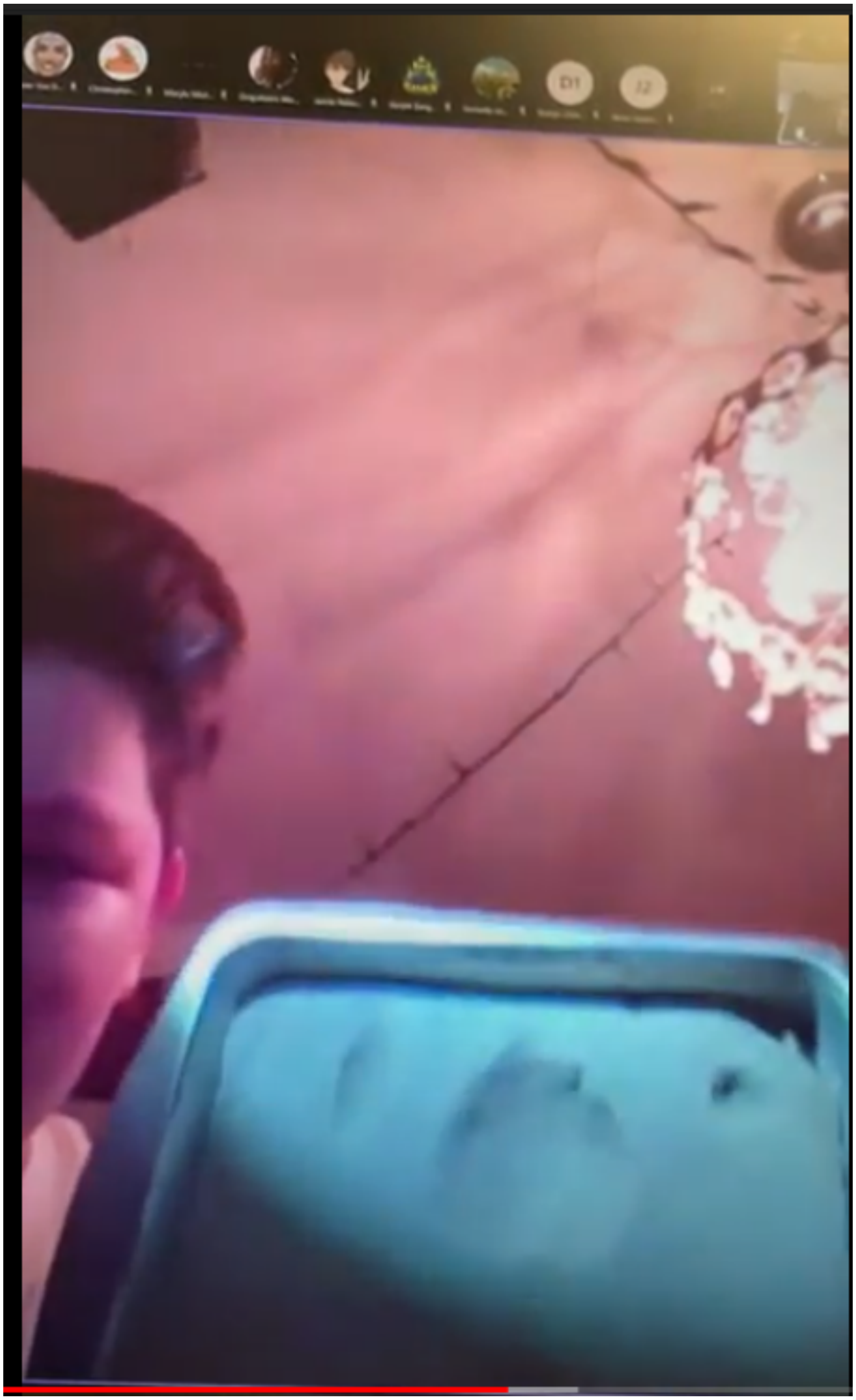


Figure 23. Student at Home Performing a Demonstration of his Experiment, Developing a Substance to Fill in Potholes, for Students at Home and in the Classroom

Case 5 Sean: Summer School Entrepreneurship Career Technical Education Framed through the Topic of Transportation

The high school case was particularly aligned with the objective to prepare students for transportation-related careers, because it was a Career Technical Education (CTE) focused project-based learning sequence. The career focus was on entrepreneurship and transportation. What made this learning experience especially powerful was that it was developed for, and then implemented in, a summer school course, which allowed the students to engage deeply with the topic and demonstrate what a rich topic transportation is.

In this case, the teacher had deep expertise of CTE and entrepreneurship. His flexible schedule during the summer school period allowed him to develop an intense instructional sequence, over two weeks, which focused on transportation, while also providing the students an opportunity to deepen their mastery of entrepreneurial skills such as empathy mapping (Table 8).

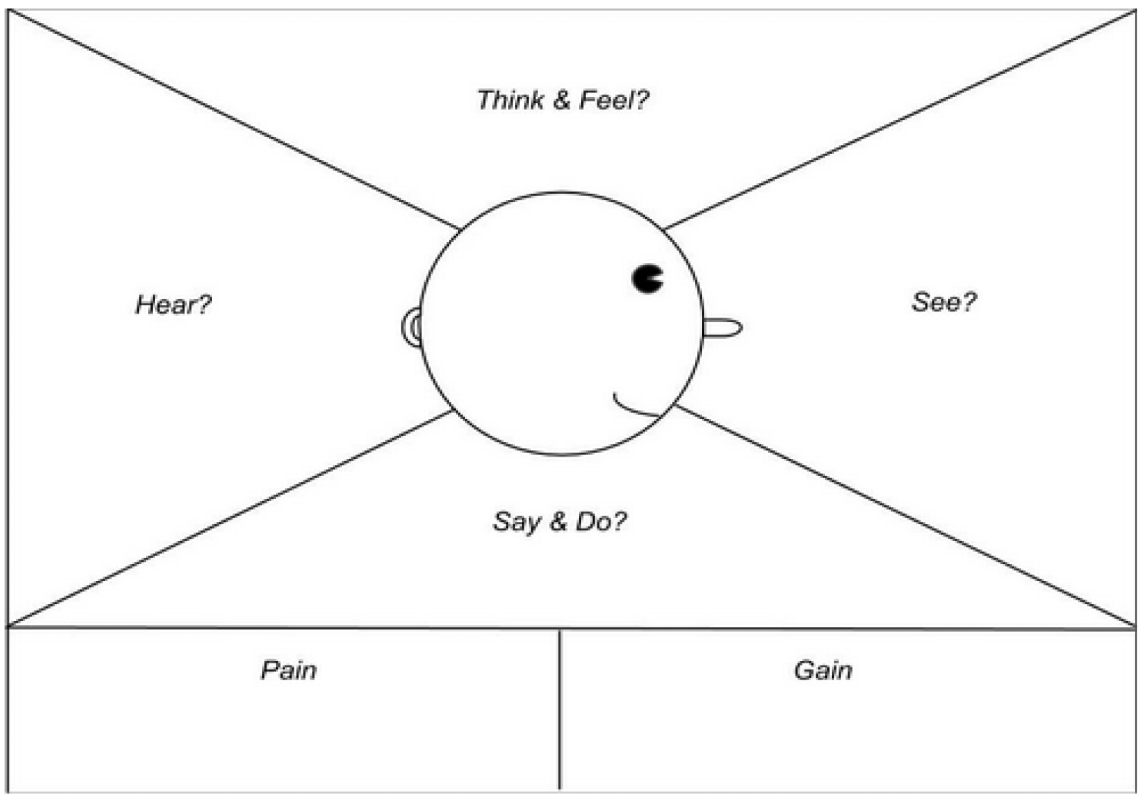
Table 8. CTE Summer School

Date	Activity
Session 1	Introduction to different modes of transportation
Session 2	Transportation Impact
Session 3–4	Historical Innovation and Impact
Session 5	Modern Technology and Innovation in Transportation
Session 6	Stakeholder Meeting
Session 7	Future of Transportation
Session 8	Design Presentation
Session 9	Presentation Rehearsal
Session 10	Presentation

The objective of the sequence was for students to use online resources to research historical innovation in transportation prior to the twentieth century, to partner with a local stakeholder in transportation to understand current trends in local innovative transportation projects, to study how technology has enabled transportation to change and solve problems for society, to report on small or large future transportation trends and predict the impact the innovation will have on society, and to present their findings. The lesson was designed to tie in to the CTE transportation anchor standards 4.5, 5.1, 5.4, and 7.5. The sequence was spread out over ten days and guided the students to learn more about different modes of transportation, their historical background, and their impact on the environment. The students were conducting stakeholder meetings to focus on current transportation issues and the future of transportation, which they presented in a final presentation.

This case study is a great example of highlighting transportation-related careers and opportunities of transportation as a career path. In this particular scenario, there was also a focus on sustainability and transportation equity because the students were encouraged to understand the stakeholders in their community better. This was achieved during Session 2 with an empathy-mapping activity, and then in Session 6 with the stakeholder meeting (Fig. 24). During the empathy-mapping activity, students were given a graphic organizer that allowed them to visually represent what their daily experience would be like if they did not have access to the transportation they use every day. The students asked themselves these questions: If you didn't have access to a car what would someone say and do? Hear? Think and feel? What pain would they feel? What would be gained by having access to, e.g., a bus? This empathy-mapping helped the students to understand the impact and importance of various modes of transportation better. This deepened understanding was then connected to the student's research of historical innovations in the field of transportation and the impact on individuals and society. This then segued into a meeting with a stakeholder who is working in the transportation industry. In this case, the university transportation students served as the transportation stakeholders. The high school students interviewed them about current local projects and examples of innovation in local transportation efforts. This allowed the students to have a first-hand experience with transportation-related careers.

Figure 24. Empathy Mapping



Session 7 – Future of Transportation

Session 7 is a great example of connecting local community matters to the content. First, the students recalled the content that they covered previously: historical innovation and transportation, current transportation, innovation, and technological trends in transportation. Then, they reflected on the stakeholder interview and started focusing on the future of transportation. At the moment, California high speed rail was a major project, which was highly visible in the Central Valley, and will greatly impact transportation. The students were prompted to imagine being able to travel to LA from Fresno in less than an hour. And they were asked to adopt the perspective of job seekers and business owners. Will this bring in more jobs? How will this impact housing and cost of living?

The students were then asked to do a scavenger hunt online, and seek out information about future projects in transportation that will lead to a positive impact for society in the near future. The students were asked to collected information from various online sites to describe and analyze future experiments in transportation. How will it improve the commute for passengers? Will this new transportation mode have a great impact on the environment? How? The students were also asked to make a prediction about how the motive transportation will impact society, job-seekers, and business owners.

This activity helped solidify the knowledge that they developed about the field of transportation and their critical thinking skills to imagine what the broader impact of transportation is on society.

Session 8, 9 and 10 – Designing, Rehearsing and Presenting the Presentations

This case is not only exemplary in the use of student teams as ways of developing and practicing collaboration skills, but it also shows how the students can practice their presentation skills. During the last two sessions, the students are asked to bring everything together and create a presentation for their peers and community.

Figure 25. Lesson plan for the Presentation

DAY 9 - SLIDE DECK DESIGN/PRESENTATION REHEARSAL

33. Warm-Up Activity - student teams will begin by identifying three goals that they will complete by the end of the day. Examples may include; finishing the slide deck based on requirements, practicing the presentation of their content, fixing any errors in our slide deck, getting feedback from other teams, and teacher feedback.

34. Activity

a. Steps/Actions- The class will be divided. Student teams who finish the slide deck the previous day will be expected to assign roles to each team member for at least one section of the presentation to deliver verbally and two run through practice trials during class. The remaining teams will continue to finish their slide deck and assign roles that they will be expected to complete before class the next day for presentations.

35. Closing - Teams will reflect on the following guided prompts and share out to the class connections discussion.

a. Describe how your team is feeling about the transportation presentation tomorrow.

b. What do you hope the class will learn from your presentation tomorrow?

c. What goals can your team create to make this hope a reality?

DAY 10 - PRESENTATION DAY

36. Warm-Up Activity - Review their slide decks, clarifying speaking parts, last minute preparedness support before class presentation.

37. Opening Discussion - remind the students that every team will deliver a presentation today telling different stories about transportation impact on society then, today, and in the future.

11

38. Instruction - During Presentations, each student in the audience will be expected to create a question they will address to the presenting team if called upon to do so. Questions need to be related to the content of the presentation.The audience will also be expected to write a closing Reflection on the Presentations they listened to today. What was the most impactful knowledge they gained from each team? Did the team that presented seemed prepared? Give evidence of this.

39. Closing - students will address the following closing prompt; describe how this project has made you think differently about transportation and where it's going to help society in the future?

Online transportation resource repository

A key feature of this project was the development of an online transportation resource repository in order to support the sustainability of transportation-related learning. The goal is to offer teachers and students an option to independently access transportation-related content, materials, and curricula to use with students. In addition, it could also serve as a mechanism to facilitate teachers' identification and the contacting of relevant university and industry experts across various transportation fields. Furthermore, this platform will provide a way for online interaction between teachers implementing projects like the Transportation *Challenge* and transportation professionals.

As lesson designers, we collaborated with teachers who excelled in their participation in the challenge, university transportation engineering students who assisted in the classrooms, professional development experts for teachers, and university faculty. We partnered with a local software company to develop this customized hub to fit our needs (Fig. 26).

A total of 65 lessons were developed, with 30 content lessons and 35 lessons as part of lesson sequences, also known as transportation challenges (see Table 9). The lessons covered all the grade levels from K–12 (see Table 10) and involved 15 different lesson designers (see Table 11). Some examples for lessons are documented in Figs. 27, 28 and 29.

A detailed description of the lessons can be found in Table 12. The general structure of the transportation challenge (Table 13) was adapted to literacy (see Table 14), to K-2 (see Table 15), and to CTE and entrepreneurship (see Table 16).

The online hub is housed at https://csu-transportation.quiqprojects.com/home-page.

Figure 26. The Homepage for the CSU Transportation Education Hub

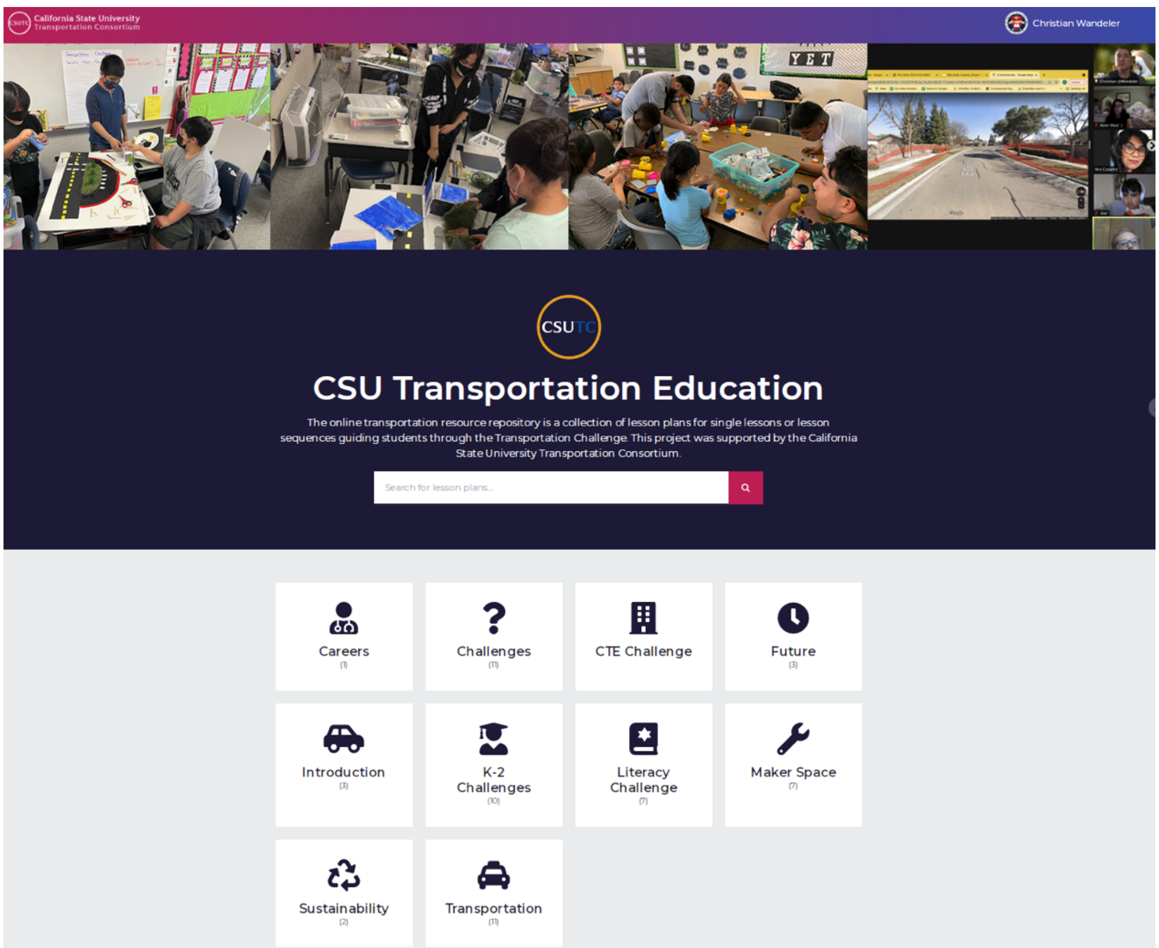


Figure 27. Example of a Challenge on the CSU Transportation Education Hub

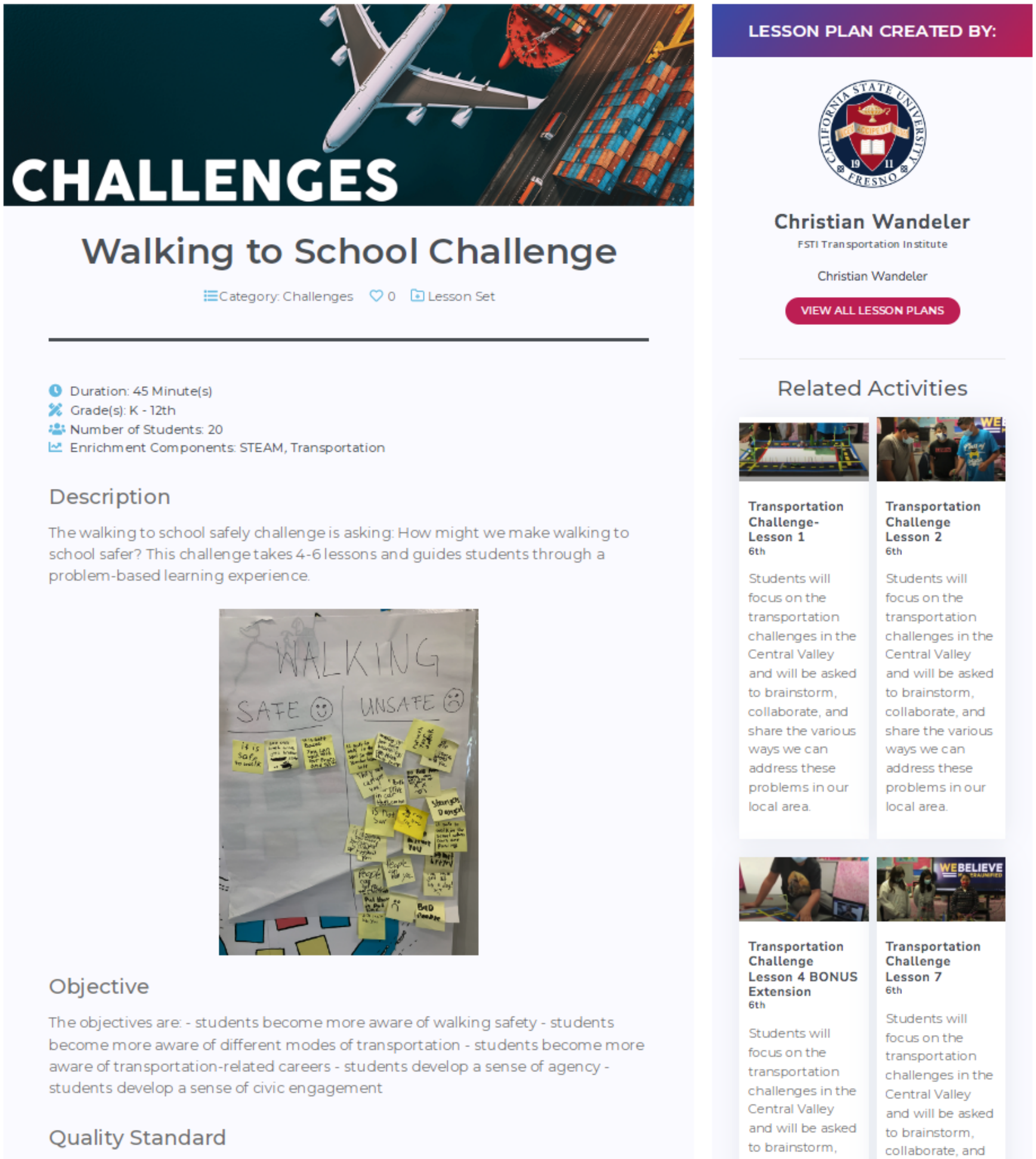


Figure 28. Example of a Lesson on Sustainability on the CSU Transportation Education Hub

Aviation and Greenhouse Emissions Iron Chef Lesson with Eduprotocols

Category: Sustainability Tags: Transportation Challenge 0 Lesson Set

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- Duration: 45 Minute(s)
- Grade(s): 6th - 9th
- Number of Students: 35
- Enrichment Components: Engineering, Transportation

Description

Students will read a scientific journal in a scaffolded activity that allows students of many levels and skills to access the information via an Iron Chef (jigsaw) style lesson.

Objective

Reading comprehension, greenhouse emissions facts, summarizing, key vocabulary, and speaking/presenting standards.

Figure 29. Example of a Maker Space Lesson on the CSU Transportation Education Hub

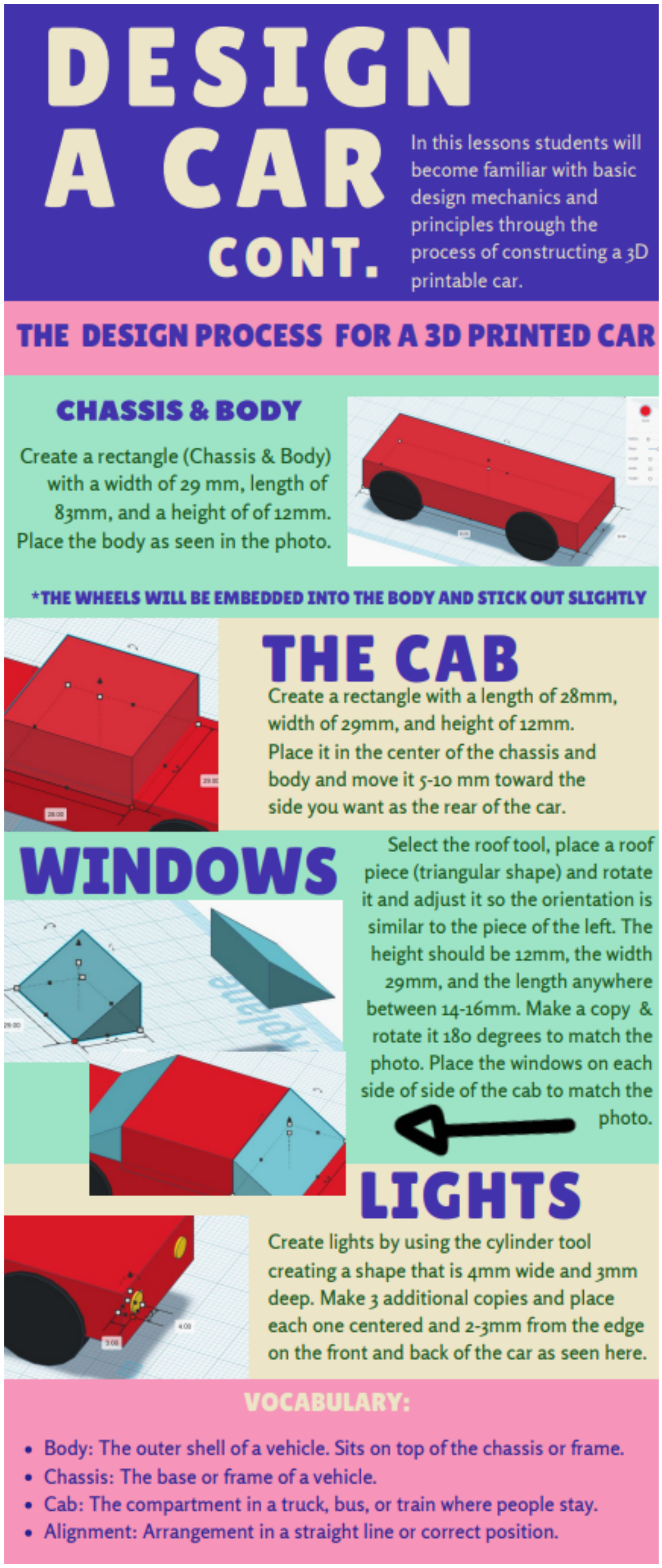
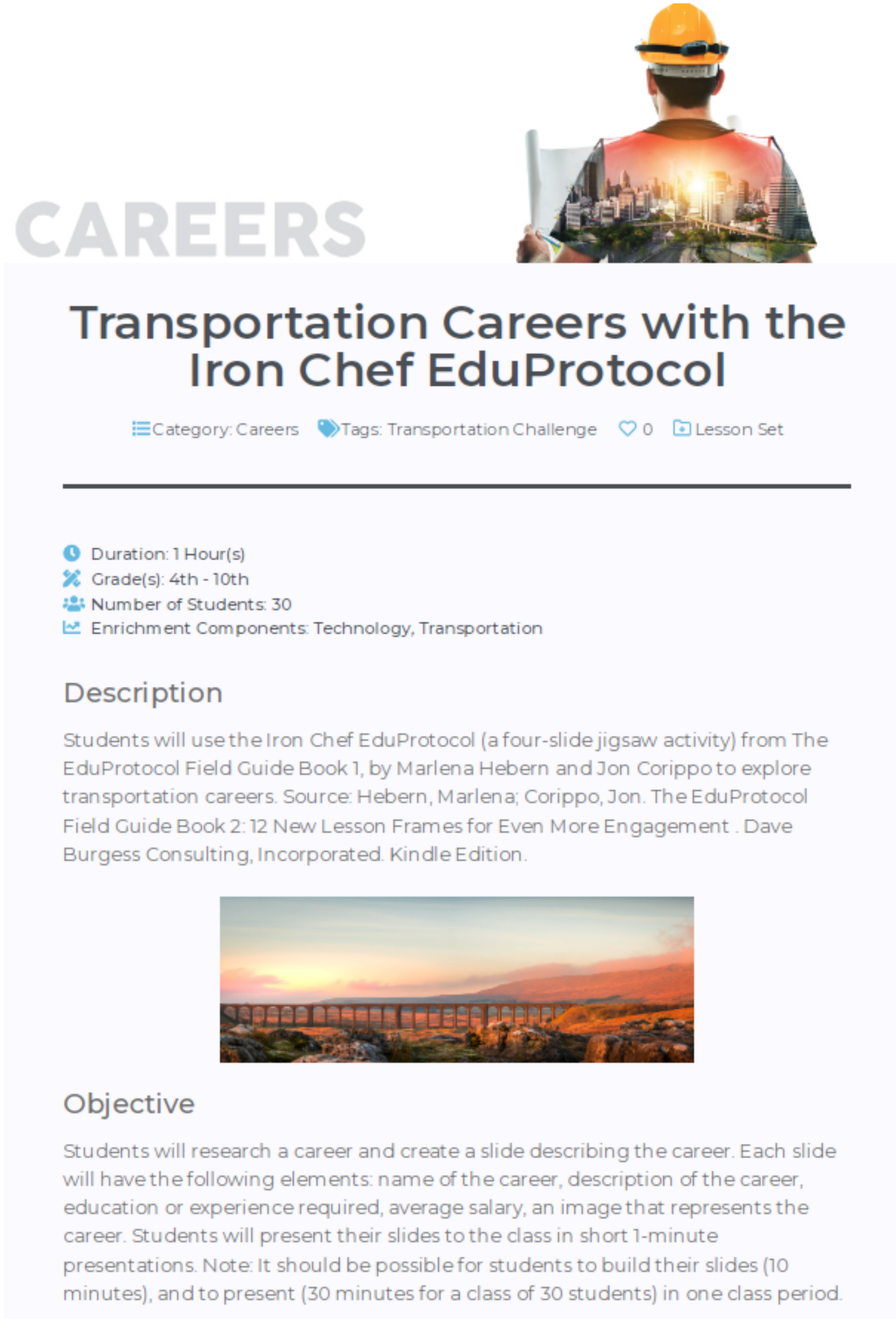


Figure 30. An Example of a Transportation Career Lesson on the CSU Transportation Education Hub


CAREERS

Transportation Careers with the Iron Chef EduProtocol

Category: Careers Tags: Transportation Challenge 0 Lesson Set

- Duration: 1 Hour(s)
- Grade(s): 4th - 10th
- Number of Students: 30
- Enrichment Components: Technology, Transportation

Description

Students will use the Iron Chef EduProtocol (a four-slide jigsaw activity) from The EduProtocol Field Guide Book 1, by Marlena Hebern and Jon Corippo to explore transportation careers. Source: Hebern, Marlena; Corippo, Jon. The EduProtocol Field Guide Book 2: 12 New Lesson Frames for Even More Engagement . Dave Burgess Consulting, Incorporated. Kindle Edition.

Objective

Students will research a career and create a slide describing the career. Each slide will have the following elements: name of the career, description of the career, education or experience required, average salary, an image that represents the career. Students will present their slides to the class in short 1-minute presentations. Note: It should be possible for students to build their slides (10 minutes), and to present (30 minutes for a class of 30 students) in one class period.

Table 9. The Different Types of Lessons and Lesson Sequences

Type of Lesson	*Number of Lessons*
Individual lessons	30
Transportation Challenge: Eight lesson sequence	8
Literacy focused Transportation Challenge: Seven lesson sequence	7
K-2 Transportation Challenge: Ten lesson sequence	10
CTE and Entrepreneurship focused Transportation Challenge: Ten lesson sequence	10

Table 10. Lessons Per Grade (some lessons applicable for various grades).

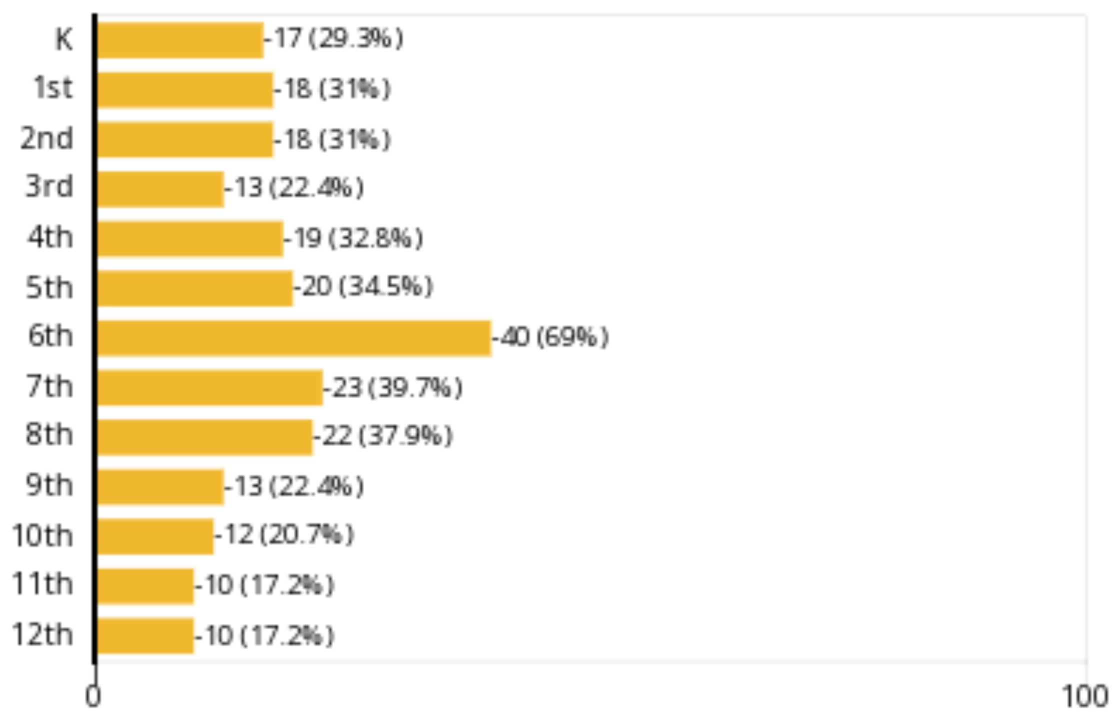


Table 11. A Total of 58 Lessons were Developed by 15 Different Lesson Designers

Grade level focus	*Lesson Designer*	*Experience level, qualifications*
K-2	Alejandra	Experienced teacher, online schooling
3-4	Gloria	Experienced teacher, online schooling
5-6	Destiny	All in-person student teacher with mentor teacher
6	Roxanne	Experienced teacher, hybrid flex
7-8	Joshua	Experienced teacher, Social Studies
4-8	Mike	Experienced teacher, Makerspace
9-12	Sean	Experienced teacher, Entrepreneurship
K–12	Jon	Professional Development Expert for Teachers
K–12	Marlena	Professional Development Expert for Teachers
K–12	Scott	Professional Development Expert for Teachers
K–12	Arun	University Transportation Engineering Student
K–12	Utsav	University Transportation Engineering Student
K–12	Dave	University Transportation Engineering Student
K–12	Subhadip	University Transportation Engineering Student
K–12	Christian	University Faculty Education

Table 12. A Total of 30 Content Lessons

1	California High Speed Rail- Debate It Eduprotocol
2	Transportation Careers with the Iron Chef Eduprotocol
3	Transportation Number Mania Eduprotocol
4	Vocabulary Lesson: The Future of Travel
5	Key Transportation Terms with The Fast and Curious & Frayer Eduprotocols
6	Aviation and Greenhouse Emissions Iron Chef Lesson with Eduprotocols
7	Future Transportation Models: Sketch and Tell with Eduprotocols
8	Intersection Safety and Management
9	Kitchen-foil Boats
10	Pedestrian Signal Timing
11	Power Boat
12	Designing Different Highway Interchanges
13	Flight Test
14	A Step Towards Sustainable Development in Transportation
15	Transportation and Climate Change Action Hour
16	Slow It Down: Learning about drag
17	Various Modes of Transportation
18	Traffic Counts and Signal Timing
19	Longer or Shorter! Learning About Distances
20	Design a 3D Printable Glider
21	Design a Train in CAD Software for 3D Printing
22	Design a Transportation Themed Name Badge
23	How to Design a Car for 3D Printing
24	How Do Students Commute to School? KWL Chart
25	Transportation Survey
26	Modes of Transportation
27	Cause and Effect Brainstorm (Day 1) Cause and Effect Introduction Paragraph (Day 2)
28	Paper Circuit
29	Mouse Trap Race Car
30	Rubber Band Propeller Powered Car

Table 13. Transportation Challenge

Transportation Challenge Lesson 1
Transportation Challenge Lesson 2
Transportation Challenge Lesson 3
Transportation Challenge Lesson 4
Transportation Challenge Lesson 4 BONUS Extension
Transportation Challenge Lesson 5
Transportation Challenge Lesson 6
Transportation Challenge Lesson 7
Transportation Challenge Lesson 8

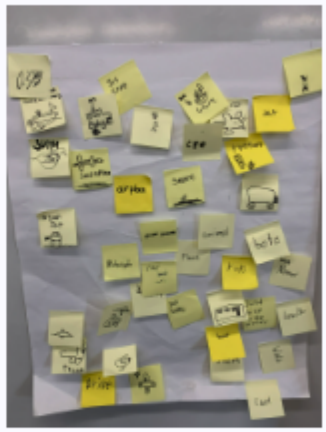
Figure 31. Example of a Transportation Challenge Lesson

Lesson 1: What Is Transportation?

Explore what is transportation,

Explore different modes of transportation

How do students get to school?



Step 1
1. Group the students in groups of 4-6 students.
2. Give each group one stack of post-it notes.
3. Ask: Who knows what the word transportation means?
What does transportation mean?
Make sure students understand the word transportation.

Step 2
4. Please in your group write down all the different modes of transportation that you can think of.
One mode of transportation per post-it
Let a representative of the group come up and share with all.

Table 14. Literacy-focused Transportation Challenge

Transportation Challenge Literacy Extension Lesson 1
Transportation Challenge Literacy Extension Lesson 2
Transportation Challenge Literacy Extension Lesson 3
Transportation Challenge Literacy Extension Lesson 4
Transportation Challenge Literacy Extension Lesson 5
Transportation Challenge Literacy Extension Lesson 6
Transportation Challenge Literacy Extension Lesson 7

Figure 32. Literacy-focused Transportation Challenge Lesson

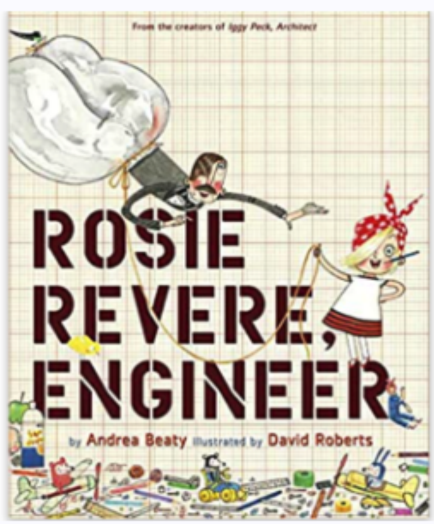
Transportation Challenge Literacy Extension Lesson 1

Category: Transportation   0   Lesson Set

- Duration: 40 Minute(s)
- Grade(s): 6th
- Number of Students: 30
- Enrichment Components: Creativity

Description

This lesson utilizes the book, "Rosie Revere, Engineer." A great literacy extension to introduce along with the first Transportation Challenge lesson. This book is an easy read that takes students on an adventure with a young girl who realizes you only fail if you quit.



Objective

Students will learn that quitting will be the only failure during this project

Table 15. K-2 Transportation Challenge: Ten Lesson Sequence

Lesson 1-Kick off
Lesson 2-Modes of Transportation
Lesson 3-Land Transportation
Lesson 4-Land Transportation
Lesson 5-Sea Transportation
Lesson 6-Sea Transportation Day 2
Lesson 7-Air Transportation
Lesson 8-Air Transportation
Lesson 9-Transportation-related issues in Community
Lesson 10-Design transportation solutions for community issues

Figure 33. K-2 Transportation Challenge Lesson

K-2 Transportation Challenge Lesson 10- Design transportation solutions for community issues

Category: K-2 Challenges   0   Lesson Set

- Duration: 30 Minute(s)
- Grade(s): K - 2nd
- Number of Students: 29
- Enrichment Components: Transportation

Description

An extension from yesterday's lesson on issues in our city/town/state

Objective

Students will think like an engineer design inventions/blueprints for ways to improve modes of transportation to help the issues in our city/town/state

Quality Standard

- Active and Engaged
- Skill Building
- Youth Voice & Leadership
- Diversity, Access, and Equity

Materials & Supplies

Items	Qty	Vendor
Google Slides	1	
blank paper	29	
pencil	29	
Flipgrid	1	

Table 16. CTE and Entrepreneurship-focused Transportation Challenge

Date	Activity
Session 1	Introduction to different modes of transportation
Session 2	Transportation Impact
Session 3-4	Historical Innovation and Impact
Session 5	Modern Technology and Innovation in Transportation
Session 6	Stakeholder Meeting
Session 7	Future of Transportation
Session 8	Design Presentation
Session 9	Presentation Rehearsal
Session 10	Presentation

4. Discussion

This project aimed to provide underserved minority students from rural areas with opportunities to examine transportation careers and engage in community transformation through high-quality educational experiences. The Central Valley Transportation Challenge provided opportunities for K–12 students and teachers to collaborate with transportation and engineering professionals from university and industry sectors in conducting civic action projects involving transportation issues to improve their communities.

Reaching the Objectives and Aligning with CSUTC Targets

The project was accomplished through three main objectives: it supported K–12 teachers' understanding and implementation of the CVTC programs; it connected K–12 students with university faculty and students, and transportation professionals through the CVTC program; and the project developed an online hub with transportation-related lesson plans and lesson sequences.

By focusing on a specific target-audience of rural and majority underserved K–12 students, the project was successful in aligning with the CSUTC target to attract and retain women and minorities in the transportation workforce. The project also aligned with the CSUTC objective to create safer communities, increased access to transit, and greater opportunities for use of active transportation modes (i.e., biking and walking) by proposing these topics in single lessons and making them topics for the transportation challenges.

Key Lessons Learned for Transportation Outreach Programs for Rural and Underserved Students

While striving to achieve the project goals, an important research question is: What can other transportation outreach programs learn from this project? The following key findings summarize some of the lessons learned from the five case studies and the development of the online hub. The case studies illustrate how different pedagogical approaches and uses of technology were implemented, and how the project connections between the schools, community members, and professionals from transportation-related fields were developed.

Key finding 1: Agility of the Program

A key characteristic of the transportation challenge is its high level of agility. The project is composed of a general foundational structure grounded in design and engineering thinking, and a sequence with key learning outcomes. While this structure provides a solid foundation, at the same time, there is enough flexibility to allow for the experience and expertise of the participating teachers, and to be responsive to the needs of the students.

The challenge was adapted for different grade levels, and, more importantly, different delivery methods. We developed a fully online experience, a hybrid experience, and an in-person experience. Although the COVID-19 environment made it more challenging to complete the project, it ultimately stress-tested our model of the transportation challenge and made it stronger.

The teachers did not necessarily have to be familiar with project-based learning. The structure and the personnel supported the implementation of the challenge and almost automatically resulted in a high-quality learning experience.

Key finding 2: Different Levels of Teacher Support and Forms of Collaboration

The collaboration between the university faculty and the teachers varied in the intensity of support and forms of collaboration. There were highly independent teachers and there were teachers who needed more support from the program staff for transportation content knowledge, and instructional strategies and/or educational technologies. The teachers had knowledge of the general skill level of their students, and, importantly, their skill level in regards to the use of technology.

Key finding 3: Collaboration Between the Different Actors

The collaboration between the different actors once more proved to be a winning formula. Leveraging the engineering students' expertise led them to become more proficient in the content and provided an opportunity for social learning. They also provided a welcome relief for the classroom teachers. They reported feeling supported by the university students, and they also did not have to feel like they were the experts. This indicates that, otherwise, they might not have considered the topic of transportation.

Therefore, leveraging university students as educational support not only provides the students with a learning experience, but might be an important resource for teachers to consider going further into transportation-related content and careers.

Key finding 4: Variations in Different Hybrid Flex Formats

There were different hybrid flex formats that emerged: Teachers in classroom and K–12 students online and partially in the classroom; teachers online and K–12 students online; and teachers and students in the classroom. The involvement of the university faculty and students also varied between being online and being live in the classroom.

Key finding 5: Raising awareness of transportation topics and careers.

The project managed to raise the students' and teachers' awareness of transportation topics and careers. The exposure to careers happened not only through targeted individual lessons, but also through direct interaction with transportation professionals. One particularly interesting practice emerged when we created an asynchronous video chat using the platform Flipgrid. The elementary school students could pose any question in Flipgrid by recording and posting a video of themselves. The university transportation students would then send them a video response. This was a very effective extension of the learning experience, and showed how stimulating the content was for students. Even after school hours, they would think about transportation and post questions.

Key finding 6: Alignment of Transportation Outreach with Academic Standards

The alignment of transportation outreach with academic standards is important for teachers and educational leaders. Another research effort could involve establishing standards of learning for Transportation Sciences for K–12. There are standards for transportation in CTE, but they could be more detailed.

Key finding 7: Sustainability of the Program with the Online Hub

To support the sustainability of transportation-related learning across subsequent years, an online transportation resource repository was created. This hub was then populated with lessons and units developed by pedagogical experts and content experts. The lessons cover the grades K–12 and range from brief lessons to very engaging and holistic two-week-long lesson sequences. The online hub platform took a lot of effort to create and is still being worked on. It is a great start and provides teachers and students with great value, but in order to truly create a sustainable program the platform has to be used.

Key finding 8: Strategic Flexibility of the Outreach Program with the Online Hub

Strategic decisions of outreach programs depend on the objectives. If the goal is to raise awareness and excitement about transportation, the approach might be different than if the goal is to facilitate deeper learning in a certain transportation domain such as highway intersection design, alternative fuels, or high-speed rail. Providing resources such as the online transportation hub could address these strategic questions by offering a range of lesson plans that vary in duration from 30 minutes to ten days, ranging from general transportation lessons to very specific lessons, and expand the lesson plans to more holistic project-based learning where students apply their transportation knowledge, through design and engineering thinking, to real world challenges in their community.

Benefits to Californians/External Support for Project

This project benefited Californians and practitioners in various ways. The main goal of this project was to engage students (primarily minority students from rural areas) in exploring transportation career opportunities in meaningful and authentic ways. As such, this project increased the interest of California youth in transportation-related careers, which hopefully matches future workplace demands for these professions. California infrastructure is predicted to need continuous work, and a qualified workforce will improve the living conditions for all Californians. Further, the

Transportation Challenge process develops students' effective citizen participatory skills, which holds the potential to empower them to become active adult citizens and voters regarding decisions related to transportation issues. Ultimately, there is strong sustainability for this project, enabling it to impart these benefits to future generations of California students. The transportation education repository will be accessible to the public, so that any teacher or citizen may use it. This tool should ensure that the current participating teachers will continue to apply this educational approach with future students and invite other interested teachers to engage in this work. Further, the public dissemination of this project across academic and public sectors should increase the likelihood that participating transportation professionals will share their experiences with, and recruit, colleagues to engage in similar work with schools in their communities, thus expanding the reach of this approach to other California students.

Abbreviations and Acronyms

CVTC	Central Valley Transportation Challenge
FSTI	Fresno State Transportation Institute

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