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Multimodal Transportation Engineering Curriculum for Middle and High School Students

Final Report

by

Washington State University, Consortium Member

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EXECUTIVE SUMMARY

Meeting the future demands of the nation's vast transportation infrastructure is a foreseeable challenge and will potentially place stress on transportation employees and researchers to meet the ongoing needs for improvements and new technologies that are safe, green, and sustainable. New transportation engineers who have been educated in multi-modal transportation options that utilize an ever-evolving and more sustainable infrastructure network will be important for discovering solutions to maintenance, operations, and alternative solutions to expansion decisions. Introducing children to transportation engineering concepts is key to helping fill this future known need, as exposure to the field, if introduced in a manner that is interesting and educational, can influence young students to consider the field as they make career decisions. Studying the factors such as lifestyle, self-efficacy and belongingness that contribute to a child's ability to learn in an online environment can help us understand how to design outreach programs that interest and attract students to engineering, meeting both the needs of the students as well as the those of the field.

This outreach program was initially designed for face-to-face delivery, but an online outreach activity was later developed to allow for the project to continue despite COVID-19 quarantine. The activity was created in the form of a Qualtrics survey and consisted of survey questions measuring self-efficacy, belongingness, and a variety of other factors, a pre-activity test pertaining to the topic of transportation engineering, links to videos explaining what a transportation engineer does and how traffic signals work, an online transportation game, a post-activity test that was identical to the pre-activity test to gauge learning, and an optional short essay about the activity. Middle and high school students were initially recruited from schools within a 60-mile radius of Pullman, WA. Since schools were online at this point, this proved ineffective as teachers were finding it difficult to motivate students to complete assignments, let alone an additional project. But due to the online format of the activity, the researchers were not bound to work with only local schools and reached out to Upward Bound Math-Science programs nationwide and incentivized students with a gift card they could win based on the quality of their essay submissions.

The t-tests and correlational analyses were run on the data collected from a total of 116 survey responses. The p-values of self-efficacy were significant when time exercising per day, time reading per day, and time using electronics per day changed. For belongingness, different age, different time reading per day, and different levels of self-efficacy resulted in statistical significance. For before/after scores, time reading per day, time using electronics per day, the level of self-efficacy, and the level of belongingness had more influence than others. There was a weak negative correlation (-0.369) between time reading per day and time using electronics per day. The correlations between time reading per day and self-efficacy and between belongingness and self-efficacy were positive and weak, which were 0.337 and 0.435 respectively. In contrast, the correlations between other variables, if any, were poorly correlated or uncorrelated, as indicated by the low correlation coefficients. Overall, when considering the t-test results and correlational coefficients together, the factor that had the most significant effect on the improvement between before and after scores was the time spent reading each day. Time spent reading had the greatest effect on self-efficacy scores and self-efficacy scores had the greatest influence on belongingness scores.

Future research should continue to explore the best methods for an entirely online outreach project. The relationships between self-efficacy and belongingness, time spent reading and learning, time spent reading and self-efficacy, electronic use and self-efficacy, and exercise and self-efficacy should be further researched as well.

Chapter 1. Introduction

1.1 Problem Statement

Workforce shortages in the transportation industry will place increased stress on transportation employees as they struggle to meet the demands of the nation's large transportation network. Newcomers to the field with a diverse background in multi-modal transportation options and training in new technologies will be critical as sustainable transportation alternatives and solutions are given increased priority during maintenance, operations, and expansion decisions. Therefore, introducing young middle- and high-school students to transportation engineering concepts is critical to their decision-making career options to help fill this future known need. By exposing students to the field of transportation engineering in interesting and educational ways, students will be more inclined to consider the field as they pursue further studies.

Extracurricular outreach events that introduce transportation engineering to students have been a proven method for increasing interest. Developing a curriculum that is engaging, hands-on, and entertaining has the potential to influence students' thoughts about transportation as a career, thus making it critical for researchers to understand and develop activities that motivate students to learn.

Outreach events allow for early exposure to the STEM fields that students may not receive from school or their households if their parents are not working in the field. STEM outreach events typically consist of hosting tables at sponsored science events where kids migrate between the tables and receive information or participate in a learning activity, working with groups of kids in blocks of time at camps, or working with a classroom of students. Outreach activities are ideally performed face-to-face, but when COVID-19 resulted in a quarantine and inability to host an in-person outreach event in cooperation with local schools, the researchers transitioned to an online format, and redesigned the project from a face-to-face event to an online format that included instructional videos, online gaming, and questions that included a voluntary essay component. By analyzing factors that influence a child's ability to learn, such as belongingness and self-efficacy, outreach events can be created to foster the most fruitful educational experience possible. Research on exclusively online outreach events is limited, so the researchers hoped to gauge students' level of learning using the online platform.

The researchers made hypotheses on the influence of factors such as belongingness and self-efficacy on a child's ability to learn in the classroom. It was hypothesized that higher self-efficacy would result in greater learning, higher belongingness would result in greater learning, less time spent watching TV would result in greater learning, less time spent using electronics (cell phone, iPad, etc.) would result in greater learning, more time spent reading would result in greater learning, and more time spent exercising would result in greater learning. By determining which of these factors influenced a child's ability to learn, outreach events can be tailored based on the factors that allow students to learn best so they can have the best learning outcome possible.

Because of COVID, local Washington and Idaho schools had been teaching online for a few weeks while students quarantined at home. This proved a challenge with this transportation engineering project, as students, according to some teachers, had “burned out” with their school work and had not been completing school assignments. Thus, while eliciting participation in the project became a challenge, it also presented a new opportunity to reach a far more broad and diverse audience. This proved to be an advantage as the researchers discovered new outlets through summer Upward Bound Math Science programs nationwide, increasing participation in the program and ensuring a diverse respondent population based on the nature of the Upward Bound Math Science Program, which is a federally funded program designed for low-income, first-generation, underrepresented, high achieving students and students with disabilities.

1.2 Objectives

The goal of this CAMMSE project was to engage local middle and high school students in transportation engineering activities that include pre- and post- testing in order to assess their learning and the factors that influenced their learning. To meet this goal, the following objectives were addressed: (1) developing age-appropriate online transportation engineering activities, (2) packaging activities with complete instructions to allow students to access the project without assistance, (3) recruiting teachers and directors to encourage student participation, (4) assessing the data to determine student learning.

1.3 Report Overview

The remainder of this report is organized as follows. Chapter 2 presents a comprehensive review of the state-of-the-art and state-of-the-practice literature. Chapter 3 provides a detailed look at how the project was administered to middle- and high-school students nationwide, and Chapter 4 describes the discussion and summary of the data and suggestions for future research.

Chapter 2. Literature Review

2.1 Introduction

This chapter provides a review of literature on the effectiveness of online learning and how lifestyle, self-efficacy and belongingness influence student learning in STEM fields.

2.2 The Effectiveness of Online Learning

Science, technology, engineering, and math (STEM) outreach events aim to expose students to STEM content enabling them to become more confident, grow an interest, and eventually pursue a career in a STEM field. Exposing students to STEM content at a young age is important for developing interest in a STEM career path later in life (Worcester et al., 2013). Outreach events provide this exposure in fun and engaging ways. In order for outreach activities to be successful, the activities and concepts must be of high interest to students, use realistic data to reflect real design considerations, should be self-contained, be completed within two hours, and should require active participation from the students (Worcester et al., 2013). Students may lose interest in the activity if it is too long, unrealistic, or involves only passive participation. A successful outreach event occurred at a week-long summer camp where female students participated in hands-on experiments, field trips, and interactions with female scientists (Levine et al., 2015). Pre- and post-camp surveys showed drastic improvements in participants' attitudes toward the applicability of science, perceived level of support for scientific study, and interest in pursuing STEM related careers (Levine et al., 2015). Another summer camp emphasized the social context of engineering design and found that participants took more STEM courses and had higher STEM self-efficacy following the camp (Demetry et al., 2009). Exposing students to STEM content encourages them to explore more classes involving the content throughout their schooling and eventually pursue a career in science, technology, engineering, and math.

Online outreach has proven to be an effective method for reaching a wide range of students from outside of one's own community. The Chemical Engineering Department at the University of Utah developed a method of online outreach that increased their outreach participation from a mere 30 to over 3800 participants (Young & Butterfield, 2014). The department created 30 chemical engineering teaching and outreach modules on their website that allowed teachers to select a module, adjust the difficulty to best fit their classroom, and adapt the activity to match their target goals (Young & Butterfield, 2014). Each module consisted of a list of materials and methods, procedures, learning outcomes, career connections, background and theory, instructional videos, and assessment questions (Young and Butterfield, 2014). By creating the content and laying it out in a simple manner for teachers to access and use, it allowed them to easily add the module to their lesson plans without extensive hassle. Online outreach also can decrease the cost of performing outreach programs as fewer supplies typically need to be purchased (Polycarpou, 2011). This means that students may not even need to be in a classroom to complete the outreach if an activity is created that requires no materials besides a computer. Online programs can incorporate multimodal learning easily, which is important as students learn best through a combination of sensory modalities (Polycarpou, 2011). Simulations can be used that mimic real-world environments that may not be able to be replicated in a traditional classroom and electronic games allow students to have fun while learning new concepts (Polycarpou, 2011). Many transportation outreach programs have implemented online aspects to their outreach, but few have made an entirely online outreach program. One program integrated educational game modules and curricula to teach concepts of intelligent transportation control and management (Liao et al., 2010). The interactive web-based traffic control simulation was introduced at high school summer camp sessions and the students indicated they were excited about the game and had more awareness of traffic engineering issues (Liao et al.,2010). Interactive online games can add a fun element to the outreach activity while still teaching students about the desired learning goals. Online outreach opens the door to many new opportunities that cannot be accessed and utilized in a classroom setting.

2.3 Early Exposure to STEM Careers

Students who are exposed to individuals in STEM careers or college students studying STEM related fields can more easily picture themselves in a STEM profession (Levine et al., 2015). This occurs as many children picture a scientist as a stereotypical older man with white hair in a lab coat if they have not interacted with real-life scientists. By showing them what real scientists look like, this stereotype can be minimized or even removed. Students with family members in a STEM career are more likely to pursue a STEM career path themselves (Zhou et al., 2017). The more exposure students have to STEM content and professions, the more comfortable and likely to pursue a career in the field they are. An outreach program that included graduate students working directly with students allowed the students to have the graduate students and faculty to look up to as scientists who are personable, real, and different from the stereotypical scientist that the students may have pictured prior to the program (Moskal et al., 2007). Being exposed to real scientists allows students to more easily picture themselves in a STEM career and allows them to realize that a STEM career is within their reach.

2.4 Self-Efficacy, Belongingness and Learning in STEM Fields

Self-efficacy can be defined as "a sense of confidence regarding the performance of specific tasks" (Lorsbach & Jinks, 1999). Academic self-efficacy focuses on the student's belief that they can succeed academically in a classroom setting. Self-efficacy is the mediator between the stereotype-activation effect and a person's behavior (Wang et al., 2017). This means that self-efficacy influences how a student stereotypes themselves and how they predict they will do, ultimately influencing how they perform. Academic self-efficacy has shown to have a direct effect on academic performance (Hampton & Mason, 2003). Many factors contribute to a student's academic self-efficacy, such as familial background, source of efficacy, and perception of the assessments they are given (Hampton & Mason, 2003). Summer workshops have improved students' self-efficacy and attitude towards science (Fraze et al., 2011). Research on how academic self-efficacy influences a student's ability to learn from a brief outreach event has not yet been tested.

The gender of the student may have an impact on the comfort level they feel in STEM environments. There are significantly more men working in STEM careers than women partially due to an identity threat that women feel when they are surrounded by men in STEM college courses and environments (Miyake et al., 2016). Outreach events are more often the first exposure that women and minority groups have to STEM when compared to males and the ethnic majority (Ivey et al., 2012). The self-efficacy and gender relationship is prominent throughout a student's education and into their career (Gnilka & Novakovik, 2017). By establishing a more welcoming environment for all groups in STEM from a young age, the students may be more comfortable in the environment throughout their schooling and lives. One study found that gender had no influence on self-efficacy, contradicting results presented in other studies (Hampton & Mason, 2003), so by gaining a better understanding of the self-efficacy of genders before they begin an outreach project, researchers can design projects that are inclusive to the needs of everyone.

Students who feel like they belong in the classroom find more success throughout their educations and lives in general. Belongingness is necessary for someone to thrive, even outside the classroom, and a lack of this attachment can influence health, adjustment, and well-being (Baemeister & Leary, 1995). There is a direct link between peer-related belongingness and positive adjustment for high school students (Van Ryzin et al., 2009). This implies that students who feel like they belong due to interactions from their peers are more likely to respond positively to their environment. There is also a relationship between teacher-related belongingness, engagement in learning, and academic autonomy for high school students (Van Ryzin et al., 2009). This suggests that students who feel like they belong due to teacher interaction are more likely to put more effort into their learning and engage themselves more in the classroom, resulting in better learning. Schools that foster a greater sense of belongingness influence many factors including greater learning and more investment in education from students (Johnson, 2009). By making students feel like they are cared for and belong in the classroom, their academic careers can be positively influenced.

2.5 Lifestyle Characteristics and Learning in Children

Exercise has proven to have positive effects on a student's ability to improve in the classroom setting. Young adults showed improvements in long-term memory following high intensity physical exercise (Frith et al., 2017). Exercise has even helped students with learning disabilities perform better in the classroom (Reynolds et al., 2003). Exercise not only can help students with learning disabilities, but it also can help students in a wide array of academic tasks. Exercise proved to significantly improve dexterity, reading, verbal fluency, semantic fluency, reading, writing, and comprehension (Reynolds et al., 2003). In a study of Japanese students, poor physical fitness correlated strongly with weak academic skills (Morita et al., 2016). It is possible that sedentary behavior is the cause of poor academic skills rather than exercise being the cause of good academic skills. More than 2 hours of sedentary behavior a day is associated with decreased academic performance in children between the ages of 5 and 17 (Tremblay et al., 2011). Overall, there is a relationship between exercise and learning that has not been explored in conjunction with outreach events.

The amount of time a student spends reading may play a role in their ability to learn. A student's reading ability is highly related to their listening skills, intelligence, and scholastic achievement (Vineyard & Bailey, 1960). If the relationship between exercise and lower academic abilities proves to be true, then reading level may be an indicator of low academic abilities. Less moderate-to-vigorous physical activity and increased sedentary time was associated with lower reading skills in elementary school boys (Haapala, 2016). The level of reading of a child was highly predictive of their academic self-concept in a longitudinal study (Chapmen et al., 2000). Children with negative self-concepts had lower word recognition, reading comprehension, and reading book levels by the end of their 3rd year in school (Chapman et al., 2000). Reading from a young age may even be able to predict how a student will do throughout their academic career. Early reading skills can be a strong predictor of later academic assessments (Cooper et al., 2014). It has not been explored how time spent reading influences a child's ability to learn in an outreach setting.

There has been vast speculation on the effects of screen time on a child's ability to learn. Excessive and inappropriate media can harm a child's development and executive functioning (Radesky & Christakis, 2016). In a study of adolescents, high screen time was associated with school disconnectedness and poor academic achievement (Trinh et al., 2015). Screen time may not harm the student's ability to learn by itself but may do so indirectly by taking time away from other, more educational, activities or influencing how a child views their abilities. High screen time has negative effects on self-esteem and can take time away from activities such as reading or doing homework that have the ability to improve academic performance (Tremblay et al., 2011).

Chapter 3. National Survey of Middle and High School Students

3.1 Introduction

Originally the researchers had planned face-to-face outreach events with middle and high school classrooms around the Pullman, Washington area to guide students through the outreach activity and administer pre- and post-tests. Following the COVID-19 quarantine and the uncertainty that schools would reopen, the researchers designed an online activity in Qualtrics that consisted of survey questions, a pre-activity test pertaining to the topic of transportation engineering, links to videos explaining what a transportation engineer does and how traffic signals work, an online transportation game, a post-activity test that was identical to the pre-activity test to gauge learning, and an optional short essay about the activity. Students were offered a certificate from Washington State University if they completed a quality optional essay. The chance to win a $75 gift card was also offered as incentive for participation and winners selected on the basis of quality of essay response.

The researchers developed an academic self-efficacy survey to discover how the self-efficacy of the students influenced their ability to learn during the activity. The survey was created by adapting the Academic Self-Efficacy and Efficacy for Self-Regulated Learning Scale created from an adaptation of Zimmerman, Bandura, and Martinez-Pons' scale (1992) with Chemers, Hu, and Garcia's scale (2001) by Rudman (n.d.) and the Children's Self-Efficacy Scale created by Bandura (2006). The two scales were combined to best incorporate the different aspects of self-efficacy and were shortened to fit better into the timeframe of the outreach activity. Some questions were reworded at the researchers' discretion to make them clearer to students. The researchers hoped to compare the self-efficacy scores to the amount the students improved between the pre-activity and post-activity tests to draw a connection between self-efficacy and ability to learn at an outreach event. The self-efficacy scores would also be compared to the gender of the students to analyze if a relationship existed between gender and academic self-efficacy. This was thought to be an especially important analysis since the students would be completing the activity from their own home rather than a classroom with other students. This may cause female students to have an elevated self-efficacy when compared to a classroom setting as they would no longer feel the identity threat of being around male students.

The researchers also developed a belongingness survey to measure how the perception of belongingness of the students influenced their ability to learn. The survey was created by adapting the School Belongingness Scale developed by Arslan and Duru (2017). The original survey was shortened to fit better into the timeframe of the activity and some questions were reworded at the researchers' discretion to make them clearer to students. The results of this survey were to be compared to the students' improvement between the pre-activity and post-activity tests to analyze how the feeling of belonging in a school setting influenced their ability to learn. The belongingness scores could also be compared to the students' genders to determine if a relationship was present between the two variables.

The pre-activity test, developed from the video content about transportation engineering as a career, highlighted the critical concepts and responsibilities of a transportation engineer. The seven-question multiple choice questionnaire was administered before and after the learning activities to gauge the level of learning with the online activities. Students were instructed to select the "I don't know" answer for a question instead of guessing if they did not know the answer to prevent students from correctly guessing while allowing the researchers to see what the participants actually knew and understood before and after the activity. The pre-activity and post-activity results were analyzed to find each student's level of improvement. The improvement was then compared with gender, self-efficacy, belongingness, physical exercise, reading, and screen time in order to test relationships.

The first video the students were instructed to watch was titled, "What does a transportation engineer do?" by Tonkin + Taylor on YouTube (https://www.youtube.com/watch?v=ksTY7JeT78w). Tonkin + Taylor is an environmental and engineering consultant company in New Zealand. The video describes what a transportation engineer does on a day-to-day basis. The video is 2 minutes and 9 seconds in duration. This video was selected because it shows what a career in transportation engineering looks like, and is short enough to keep students interested but informative enough to educate them. It is narrated by an energetic and enthusiastic Senior Transportation Engineer who works for Tonkin +Taylor. His engaging personability may help students imagine themselves in a similar career. Following the video, participants were asked "What surprised you about a transportation engineer?" and "Was there anything that interested you?" to allow them to engage with the video content immediately and think about what they learned.

The second video was titled, "How Do Traffic Signals Work?" by Practical Engineering, which is a YouTube channel that teaches a variety of engineering topics for students (https://www.youtube.com/watch?v=DP62ogEZgkI&vl=en). The video is 12 minutes and 36 seconds in duration. The video begins by reminding students of the familiar concept of traffic and then elaborates on how traffic engineers control the flow of traffic in urban areas. Different types of traffic signals are explained, and helpful graphics are shown to solidify concepts. This video was selected as it is informative, discusses how important the role of a transportation engineer is, and relays information that is most likely familiar to most participants. For example, most everyone has sat at a traffic signal wondering why the light would not turn green. This video shows participants the science behind this common, real-world concern. Following this video the participants were asked "What type of area do you live in?" with multiple choice options of rural and urban and "What surprised you about the video?" to again engage the students with the video content immediately and apply it to their lives.

The transportation game consisted of a series of levels that slowly increase in difficulty while the players guide vehicles from four directions through traffic signals. It is available from http://www.engineering.com/gamespuzzles/trafficator.aspx. While there were 15 levels available, the students were asked to play through only the first five to fit within the timeframe of the activity. There were easy, medium, and hard difficulty levels available and the students were instructed to select the easy level. The game consisted of an overhead view of a layout including traffic lights, multiple lanes of traffics, and crosswalks. The participant would click on a car to make it stop and click on it again to make it move when the timing was right. Participants had to decide when to stop traffic from one direction to let the other direction go. Some levels included crosswalks where pedestrians would cross the road at random intervals. If the participant caused two vehicles to crash, caused a traffic jam, or hit a pedestrian, they would have to restart the level. The game enforced the challenge associated with creating traffic flow and coordinating traffic signals, allowing participants to gain a new understanding of one of the roles of a transportation engineer.

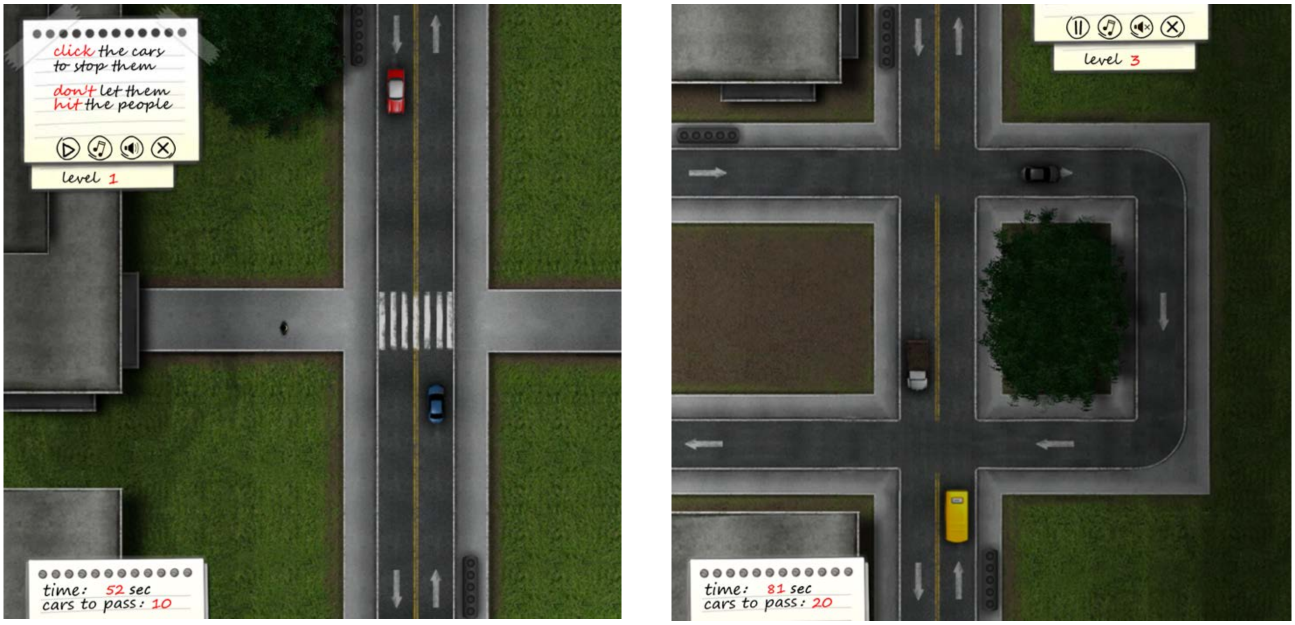

Figure 1. Image of the first and third levels of the transportation game.

The final section of the activity asked students to write a short essay of about 300 words on what they learned in the activity. Students were told that by completing the voluntary essay, they would receive a certificate of completion from Washington State University and that the most thoughtful and quality essays would receive a distinguished certificate. Students were well informed that the essay activity was optional. This section of the activity enabled researchers to see how well the students understood the key concepts of the activity and to gauge the struggles students encountered during the project.

3.2 Recruitment

Initially, 47 science teachers or principals at middle schools and high schools within a 60-mile radius of Pullman, WA were emailed. Teachers were incentivized with a $50 gift card if they encouraged their students to participate. At this point, all schools had moved to online teaching because of COVID-19, so students were familiar with online learning. However, teachers were having a difficult time with students not completing assignments. One teacher commented that her students had “checked out” of school work.

But because of the online format, the researchers were no longer bound to work only with local schools, so then reached out to Upward Bound Math-Science programs nationwide to, hopefully, include the project into their summer program curriculum. Upward Bound Math-Science provides educational summer activities specifically for low-income, underrepresented, students and students with disabilities. The program has a long history of success and allowed us to reach out to a more diverse audience than when working locally. To incentivize participation, the researchers added the chance for students to win a $75 gift card in their recruitment email. They created a website and flyer for easy access to information, and for directors and teachers to post they flyer and/or forward the information to other interested educators.

Figure 2. Flyer to recruit middle and high school students, posted https://tridurle.wsu.edu/k12-project/

Upward Bound Math Science is one of several federally funded TRIO programs specifically designed to help strengthen skills in math and science and is offered to students who have high abilities in this area. Students who participate in the Upward Bound Math-Science program are typically first-generation college students, and the majority of students who complete the program do go on to attend college. The students recruited from local high schools are of varying socioeconomic statuses and education levels of parents. This new outreach resulted in a more broad and diverse body of participants in the survey

148 Upward Bound Math-Science directors in 35 states were emailed. The contact information for each program was found online at https://www2.ed.gov/programs/trioupbound/awards.html.

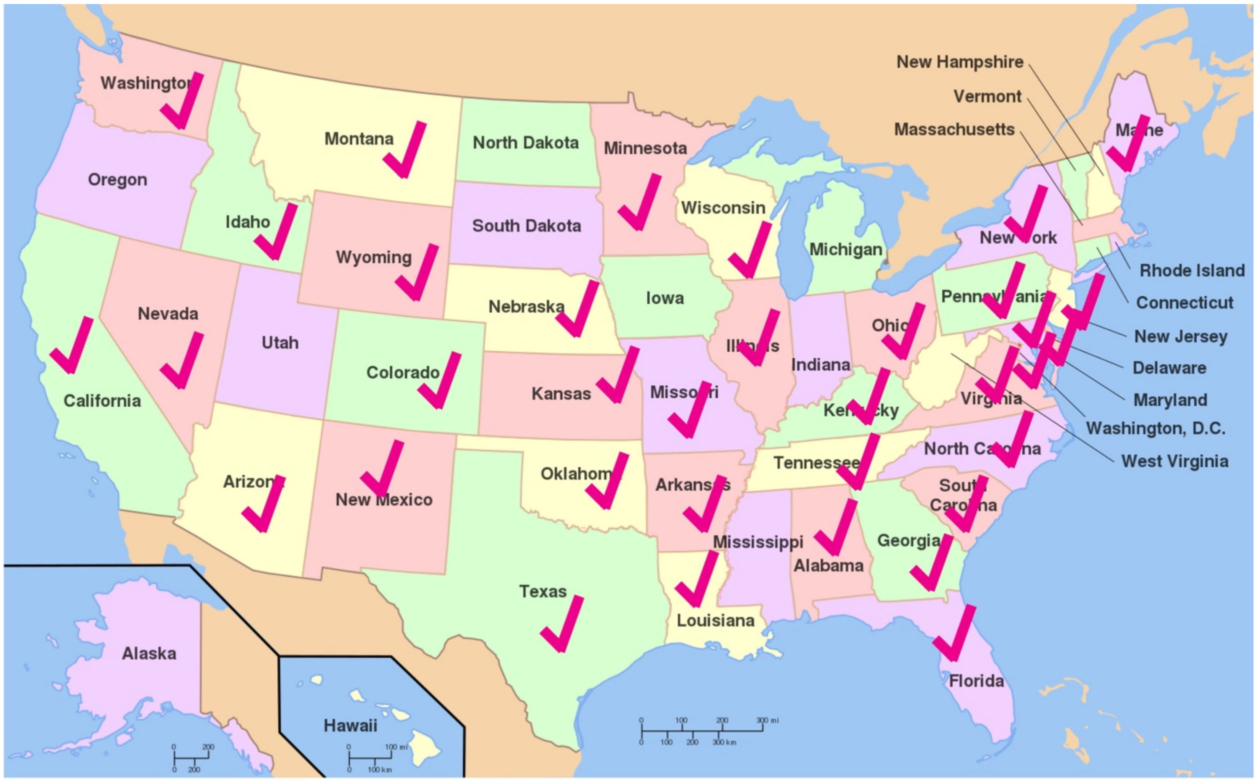

Figure 3. State Upward Bound programs contacted for participation in the survey. Most states have more than one program; i.e. California has 16 programs throughout the state.

3.3 Survey Analysis

3.31 T-Test Analysis

Based on the 116 survey responses, the two-tailed student's t-test (McDonald 2009) was conducted to examine whether a section’s total score influenced by a factor has statistically significant difference to the same section’s total score influenced by other factors. A two-tailed student's t-test is a way to compute the statistical significance of a parameter of a dataset, in terms of a test statistic that follows a student's t-distribution under the null hypothesis. A two-tailed test is suitable for use when a sample is greater or less than a certain range of values. The p-value only indicates if the difference is statistically significant. A p-value less than 0.200 indicated strong evidence against the null hypothesis that there was no statistical significance between two groups that were influenced by different factors. All measured factors were compared rather than only those involved in the hypotheses because the data was available, allowing for the possibility of finding unexpected relationships between factors.

Table 1 displays the p-values of the section's total scores and all these p-values are less than 0.200. The other p-values greater than 0.200 are not shown in the table. From the table we can see the p-values of self-efficacy were significant with time exercising per day, time reading per day, and time using electronics per day changed. Time reading per day presented the largest effect on self-efficacy followed by time using electronics per day and then time exercising per day. For belongingness, different age, different time reading per day, and different levels of self-efficacy resulted in a statistically significant difference. Belongingness had the most statistically significant difference when low self-efficacy was compared with high self-efficacy and moderate self-efficacy was compared with high self-efficacy. For before/after scores, time reading per day, time using electronics per day, the level of self-efficacy, and the level of belongingness had more influence than others, and the before/after score had the most statistically significant difference when belongingness changed.

Table 1. P-values from two-tailed student's t-test for section's total scores, comparing a factor to another factor

Factor		P-value of	
Time exercising per day	0.5-1 hour vs 2+ hours	Self-efficacy	0.131
Time reading per day	0-0.5 hour vs 1-2 hours		0.001
	0-0.5 hour vs 2+ hours		0.067
	0.5-1 hour vs 1-2 hours		0.004
	0.5-1 hour vs 2+ hours		0.171
	1-2 hours vs 2+ hours		0.155
Time using electronics per day	0-1 hour vs 2-3 hours		0.137
	0-1 hour vs 6+ hours		0.082
	4-5 hours vs 6+ hours		0.109
Age	Between 11-12 vs between 13-14	Belongingness	0.150
	Between 11-12 vs between 15-18		0.175
Time reading per day	0-0.5 hour vs 2+ hours		0.164
	1-2 hours vs 2+ hours		0.184
Self-efficacy	Low vs Moderate		0.161
	Low vs High		0.004
	Moderate vs High		0.006
Time reading per day	0-0.5 hour vs 1-2 hours	Before/after scores	0.129
	0.5-1 hour vs 1-2 hours		0.179
Time using electronics per day	0-1 hour vs 2-3 hours		0.164
Self-efficacy	Low vs Moderate		0.133
Belongingness	Low vs Moderate		0.047
	Moderate vs High		0.106

3.32 Correlation Analysis

Correlation analysis was conducted to analyze the strength of relationship between various variables. A high correlation (e.g., correlation coefficient is close to 1) indicates that two variables are highly related, while a weak correlation (e.g., correlation coefficient is close to 0) means that two variables have a weak relationship. In this study, it was defined that two variables are highly correlated if the absolute value of correlation coefficient is greater than 0.7; two variables are weakly correlated if the absolute value of correlation coefficient is between 0.3 and 0.7; two variables are poorly correlated if the absolute value of correlation coefficient is between 0.1 and 0.3; and two variables are uncorrelated if the absolute value of correlation coefficient is less than 0.1. Correlation analysis was also conducted between all factors rather than just those involved in the hypotheses as this allowed for an examination of all collected data to find any relationships that were present between the factors.

Table 2 shows the results of the correlation analysis. There was a weak negative correlation (-0.369) between time reading per day and time using electronics per day. The correlations between time reading per day and self-efficacy and between belongingness and self-efficacy were positive and weak, which were 0.337 and 0.435 respectively. In contrast, the correlations between other variables, if any, were poorly correlated or uncorrelated, as indicated by the low correlation coefficients.

Table 2. Correlation coefficients for each of the factors compared to each of the other factors

Variable	Age	Gender	Time watching TV per day	Time using electronics (cell phone, iPad, etc.) per day	Time exercising per day	Time reading per day	Self-efficacy	Belongingness	Before/after scores
Age	1	0.165	0.198	0.191	-0.124	-0.123	0.071	-0.079	0.142
Gender		1	-0.037	0.019	-0.188	0.090	0.139	-0.004	0.053
Time watching TV per day			1	-0.033	-0.033	-0.047	0.013	0.120	0.080
Time using electronics (cell phone, iPad, etc.) per day				1	0.205	**-0.369**	-0.164	-0.078	-0.014
Time exercising per day					1	-0.013	-0.117	0.035	-0.097
Time reading per day						1	**0.337**	-0.068	0.180
Self-efficacy							1	**0.435**	0.068
Belongingness								1	-0.029
Before/after scores									1

Chapter 4. Summary and Conclusions

4.1 Summary and Conclusions

The following findings were based on the analysis of a total of 116 survey responses.

4.11 Before/After Scores

It was predicted that higher academic self-efficacy scores would result in higher before/after score improvement on the content questions. The low and moderate self-efficacy participants had a statistically significant difference in their before/after improvement on the content questions with a p-value of 0.133. There was not a significant difference between the low and high self-efficacy or medium and high self-efficacy groups. The correlation coefficient for self-efficacy and before/after scores was 0.068, indicating no correlation present. This indicates that there likely was no relationship between self-efficacy scores and learning in the online outreach setting.

It was hypothesized that higher belongingness scores would cause higher improvement between the before and after content questions. The low and moderate belongingness groups had a statistically significant difference in the improvement on the content related questions with a p-value of 0.047. This is a very significant value and suggests that the null hypothesis is unlikely. The moderate and high belongingness groups also had a statistically significant difference on the improvement on the content questions with a p-value of 0.106. There was not a significant difference between the low and high belongingness groups on the improvement on the content questions. The belongingness scores and the before/after scores had a correlation coefficient of -0.029 indicating that there was no correlation. The results from the tests suggest that a relationship is not present.

Researchers hypothesized that more time spent reading would result in higher improvement between the before and after content scores. The 0-0.5 hour and 1-2 hours of reading groups had a statistically significant difference in their before/after content scores with a p-value of 0.129 and the 0.5-1 hour and 1-2 hours of reading groups also had a statistically significant difference on the before/after scores with a p-value of 0.179. The reading times and before/after content scores had a correlation coefficient of 0.180 indicating a poor correlation. The combination of the t-test results and correlation analysis suggests that a very weak relationship may be present between time spent reading and level of learning.

The 0-1 hour and 2-3 hours of time using electronics groups had a significant difference in before and after scores with a p-value of 0.164. The screen times and before/after scores had a correlation coefficient of -0.014 indicating no correlation was present. The lack of significant t-test results from the majority of the groups in this factor and the lack of a correlation suggest that time using electronics does not influence learning.

Gender, time spent watching TV, and time exercising did not influence before/after scores as none of the groups produced significantly significant p-values or correlational coefficients. For online outreach events, these factors did not influence learning.

Overall, the factor that had the most significant effect on the improvement between before and after scores was the time spent reading each day. This indicates that the time spent reading per day may have a weak influence on a child's ability to learn in an outreach setting.

4.12 Belongingness

The 0-0.5 hour and 2+ hours of reading groups had a statistically significant difference in their belongingness scores with a p-value of 0.164. The 1-2 hours and 2+ hours also had a statistically significant difference in their belongingness with a p-value of 0.184. The reading times and before/after content scores had a correlation coefficient of -0.068 indicating no correlation was present. Due to the high p-values in our range and the lack of a correlation, it can be determined that a relationship was not found.

The low and moderate, low and high, and moderate and high self-efficacy groups all had statistically significant differences in belongingness scores with respective p-values of 0.161, 0.004, and 0.006. When comparing both the low and moderate self-efficacy groups to the high self-efficacy group in belongingness scores, the p-values were very close to zero, indicating a very strong relationship. This suggests that self-efficacy may play a role in belongingness in the classroom. The self-efficacy and belongingness scores had a correlation of 0.435 indicating a weak correlation was present. The combination of the significant p-values and weak correlation suggest that a relationship between belongingness and self-efficacy is present.

The ages of 11-12 and 13-14 had a statistically significant difference in their belongingness with a p-value of 0.150. The ages of 11-12 and 15-18 had a statistically significant difference in their belongingness with a p-value of 0.175. Age and belongingness scores had a correlation coefficient of -0.079, indicating no correlation was present. While the p-values suggest a relationship, they are higher within the accepted range for this experiment. The combination of the high p-values and lack of a correlation indicate that a relationship was not present between age and belongingness.

Gender, time spent exercising, time spent watching TV, and time spent using electronics did not have statistically significant differences in belongingness scores on either the t-tests or the correlational data. These factors did not influence a child's feeling of belongingness.

Overall, self-efficacy scores had the greatest influence on belongingness scores. The other factors either had no influence or little influence on the belongingness scores.

4.13 Self-Efficacy

The 0-0.5 hour and 1-2 hours, 0-0.5 hours and 2+ hours, 0.5-1 hour and 1-2 hours, 0.5-1 hour and 2+ hours, and 1-2 hours and 2+ hours of reading groups all had significant differences in self-efficacy scores with p-values of 0.001, 0.067, 0.004, 0.171, and 0.155. The reading times and self-efficacy scores had a correlation coefficient of 0.337 indicating a weak correlation. While some of the reading time groups did not produce significant results from the t-test, the combination of the significant t-test results and correlation analyses suggest that reading and self-efficacy scores are related.

The 0-1 hour and 2-3 hours, 0-1 hour and 6+ hours, and 4-5 hours and 6+ hours of time spent using electronics groups had significant differences on self-efficacy scores with respective p-values of 0.137, 0.082, and 0.109. The screen times and self-efficacy scores had a correlation coefficient of -0.164 indicating a poor correlation was present. The significant results from many of the t-tests for this factor and the poor correlation suggest that a relationship may be present between time spent using electronics and self-efficacy scores. This relationship should be further explored.

The 0.5-1 hour and 2+ hours of exercise groups were significantly different in self-efficacy scores with a p-value of 0.131. The exercise times and self-efficacy scores had a correlation coefficient of -0.117 indicating a poor correlation was present. The correlation analysis indicated that as students spend more time exercising, their academic self-efficacy decreases. The majority of the time spent exercising groups did not produce significant results from the t-tests. The lack of significant results from most of the t-tests and the poor correlation indicate that if a relationship is present, it is very weak. Further research could examine this relationship more.

Age, gender, and time spent watching TV did not influence self-efficacy in the online outreach setting as the t-tests and correlational analysis for these factors did not produce significant results.

Overall, time spent reading had the greatest effect on self-efficacy scores. The other factors either were very weakly related or were not related to self-efficacy scores. Further research should be collected to explore the effect of time spent using electronics and time spent exercising on self-efficacy.

4.14 Other

It is possible that some of the variables that were concluded to have no effect in this study would have an effect if the outreach activity were performed in a classroom setting. The environment may have influenced students' answers and perceptions of variables such as belongingness as one typically feels more welcomed in their own home, where many of the participants probably completed the activity. It is also possible that answers to some of the variables, such as screen time, were influenced by the COVID-19 outbreak as this allowed for students to spend more time at home. Students may have answered the questions as a reflection of their time in quarantine rather than their typical habits.

4.2 Directions for Future Research

This project explored the feasibility of conducting a completely online outreach event. The project explored methods of recruiting participants and engaging students in this new online format. Online outreach events should continue to be explored due to the rapidly changing technology available to students. The best methods for distributing and encouraging participation for online outreach should be further explored. The directionality of the relationship between belongingness and self-efficacy should be examined as a relationship exists but it cannot be determined which causes the other or if they are caused by a third external variable. The relationship between time spent reading and ability to learn from outreach events should be looked into further. The relationship between time spent reading and self-efficacy should also be examined. Further research should examine the relationship between electronic use and self-efficacy scores and between exercise and self-efficacy scores as a poor correlation was found for both. By determining what variables contribute to a child's success in outreach projects, projects can be developed that tailor to more students' needs.

References

Arslan, G., & Duru, E. (2017). Initial development and validation of the school belongingness scale. *Child Indicators Research*, 10(4), 1043-1058.

Bandura, A. (2006). Guide for constructing self-efficacy scales. *Self-Efficacy Beliefs of Adolescents*, *5*(1), 307-337.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117(3), 497-529. doi:http://ntserver1.wsulibs.wsu.edu:2099/10.1037/0033-2909.117.3.497

Chapman, J. W., Tunmer, W. E., & Prochnow, J. E. (2000). Early reading-related skills and performance, reading self-concept, and the development of academic self-concept: A longitudinal study. *Journal of Educational Psychology*, 92(4), 703-708. Retrieved from https://ntserver1.wsulibs.wsu.edu:2152/docview/85524770?accountid=14902

Cooper, B. R., Moore, J. E., Powers, C. J., Cleveland, M., & Greenberg, M. T. (2014). Patterns of early reading and social skills associated with academic success in elementary school. *Early Education and Development,* 25(8), 1248-1264.

Demetry, C., Hubelbank, J., Blaisdell, S. L., Sontgerath, S., Nicholson, M. E., Rosenthal, L., & Quinn, P. (2009). Supporting young women to enter engineering: Long-term effects of a middle school engineering outreach program for girls. *Journal of Women and Minorities in Science and Engineering*, *15*(2).

Fraze, L. B., Wingenbach, G., Rutherford, T., & Wolfskill, L. A. (2011). Effects of a recruitment workshop on selected urban high school students' self-efficacy and attitudes toward agriculture as a subject, college major, and career. *Journal of Agricultural Education*, *52*(4), 123-135.

Frith, E., Sng, E., & Loprinzi, P. D. (2017). Randomized controlled trial evaluating the temporal effects of high-intensity exercise on learning, short-term and long-term memory, and prospective memory. *European Journal of Neuroscience*, 46(10), 2557-2564.

Gnilka, P. B., & Novakovic, A. (2017). Gender differences in STEM students' perfectionism, career search self-efficacy, and perception of career barriers. *Journal of Counseling & Development*, *95*(1), 56-66.

Haapala, E. A., Väistö, J., Lintu, N., Westgate, K., Ekelund, U., Poikkeus, A. M., Brage, S., & Lakka, T. A. (2017). Physical activity and sedentary time in relation to academic achievement in children. *Journal of Science and Medicine in Sport*, 20(6), 583-589.

Hampton, N. Z., & Mason, E. (2003). Learning disabilities, gender, sources of efficacy, self-efficacy beliefs, and academic achievement in high school students. *Journal of School Psychology*, *41*(2), 101-112.

Ivey, S. S., Golias, M. M., Palazolo, P., Edwards, S., & Thomas, P. (2012). Attracting students to transportation engineering: Gender differences and implications of student perceptions of transportation engineering careers. *Transportation Research Record*, *2320*(1), 90-96.

Johnson, L. S. (2009). School contexts and student belonging: A mixed methods study of an innovative high school. *School Community Journal*, *19*(1), 99-118.

Levine, M., Serio, N., Radaram, B., Chaudhuri, S., & Talbert, W. (2015). Addressing the STEM gender gap by designing and implementing an educational outreach chemistry camp for middle school girls. *Journal of Chemical Education*, *92*(10), 1639-1644.

Liao, C. F., Glick, D. B., Haag, S., & Baas, G. (2010). Development and deployment of traffic control game: Integration with traffic engineering curriculum for teaching high school students. *Transportation Research Record*, *2199*(1), 28-36.

Lorsbach, A., & Jinks, J. (1999). Self-efficacy theory and learning environment research. *Learning Environments Research*, *2*(2), 157-167.

McDonald, J.H., 2009. Handbook of biological statistics. Baltimore, MD: sparky house publishing. http://www.uni-koeln.de/math-nat-fak/genetik/groups/Langer/HandbookBioStatSecond.pdf

Miyake, A., Kost-Smith, L. E., Finkelstein, N. D., Pollock, S. J., Cohen, G. L., & Ito, T. A. (2010). Reducing the gender achievement gap in college science: a classroom study of values affirmation. *Science (New York, N.Y.)*, 330(6008), 1234–1237. https://doi.org/10.1126/science.1195996

Morita, N., Nakajima, T., Okita, K., Ishihara, T., Sagawa, M., & Yamatsu, K. (2016). Relationships among fitness, obesity, screen time and academic achievement in Japanese adolescents. *Physiology & Behavior*, 163, 161-166.

Moskal, B. M., Skokan, C., Kosbar, L., Dean, A., Westland, C., Barker, H., ... & Tafoya, J. (2007). K-12 outreach: Identifying the broader impacts of four outreach projects. *Journal of Engineering Education*, *96*(3), 173-189.

Polycarpou, Irene. (2011). Using technology to enhance K-12 outreach in materials science. *MRS Bulletin* 36(4), 290.

Radesky, J. S., & Christakis, D. A. (2016). Increased screen time: Implications for early childhood development and behavior. *Pediatric Clinics of North America*, 63(5), 827–839. https://doi.org/10.1016/j.pcl.2016.06.006

Reynolds, D., Nicolson, R. I., & Hambly, H. (2003). Evaluation of an exercise-based treatment for children with reading difficulties. *Dyslexia*, *9*(1), 48-71.

Rudman, J., (n.d). *Academic Self-Efficacy and Efficacy for Self-Regulated Learning.* Irvine Valley College.

Tremblay, M. S., LeBlanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C., Goldfield, G., & Gorber, S. C. (2011). Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, 8(1), 98.

Trinh, L., Wong, B., & Faulkner, G. E. (2015). The independent and interactive associations of screen time and physical activity on mental health, school connectedness and academic achievement among a population-based sample of youth. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, 24(1), 17.

Van Ryzin, M. J., Gravely, A. A., & Roseth, C. J. (2009). Autonomy, belongingness, and engagement in school as contributors to adolescent psychological well-being. *Journal of Youth and Adolescence*, *38*(1), 1-12.

Vineyard, E. E., & Bailey, R. B. (1960). Interrelationships of reading ability, listening skill, intelligence, and scholastic achievement. *Journal of Developmental Reading*, 3(3), 174-178.

Wang, P., Zhou, P., Tan, C. H., & Zhang, P. C. (2017). Effect of self-efficacy in stereotype activation. *Social Behavior and Personality: An International Journal*, *45*(3), 469-476.

Worcester, A. C., Hickox, V. M., Klimaszewski, J. G., Wilches-Bernal, F., Chow, J. H., & Chen, C. F. (2013). The sky's the limit!: Designing wind farms: A hands-on STEM activity for high school students. *IEEE Power and Energy Magazine*, *11*(1), 18-29.

Young, C., & Butterfield, A. E. (2014). Effective Engineering Outreach through an Undergraduate Mentoring Team and Module Database. *Chemical Engineering Education*, *48*(1), 31-36.

Zhou, B., Anderson, C., Wang, F., & Li, L. (2017). Perceptions and Preferences of High School Students in STEM: A Case Study in Connecticut and Mississippi. *Systemics, Cybernetics, and Informatics*, 23-26.

Appendix A: Survey Recipients

Schools and Programs Contacted
Upward Bound Math Science Programs Contacted

Program	State
Bevill State Community College	AL
Northwest-Shoals Community College	AL
University of Montevallo	AL
Arkansas Tech University	AR
University of Arkansas/ Fayetteville	AR
Northern Arizona University	AZ
Cal Poly Pomona Foundation, Inc.	CA
California Lutheran University	CA
California State University/ Los Angeles	CA
Compton Community College	CA
Imperial Community College District	CA
Los Angeles Valley College	CA
Loyola Marymount University	CA
Monterey Peninsula College	CA
Pasadena City College	CA
Pasadena City College	CA
Reedley College	CA
Santiago Canyon College	CA
Sonoma State University	CA
University of California/ San Diego	CA
University of Southern California	CA
University of Southern California/ Los Angeles	CA
Wahupa Educational Enterprises, Inc.	CA
West Hills College/ Lemoore	CA
West Los Angeles College	CA
West Los Angeles College	CA
Adams State University	CO
LULAC National Educational Service Centers	CO
Pueblo Community College	CO
Central Connecticut State University	CT
Wesleyan University	CT
Howard University	DC
Delaware Technical & Community College/ Owens	DE
Delaware Technical & Community College/ Wilmington	DE
University of Delaware	DE

Florida A&M University	FL
Florida Atlantic University	FL
Florida International University	FL
Indian River State College	FL
Atlanta Metropolitan State College	GA
Community Teen Coalition	GA
Kennesaw State University	GA
Morehouse College	GA
Morehouse College	GA
Morehouse College	GA
University of Georgia	GA
University of Hawaii/ Hilo	HI
University of Hawaii/ Maui College	HI
Idaho State University	ID
University of Idaho	ID
Carl Sandburg College	IL
Introspect Youth Services, Inc.	IL
University of Kansas	KS
University of Kansas	KS
Wichita State University	KS
Berea College	KY
Morehead State University	KY
Morehead State University	KY
Murray State University	KY
COPE, Inc.	LA
Southeastern Louisiana University	LA
Southern University/ New Orleans	LA
University of Louisiana/ Lafayette	LA
Xavier University of Louisiana	LA
Boston University	MA
Fitchburg State University	MA
Middlesex Community College	MA
Mount Wachusett Community College	MA
University of Massachusetts/ Boston	MA
Baltimore City Community College	MD
Frostburg State University	MD
University of Maryland/ Baltimore	MD
Northern Michigan University	MI
University of Michigan	MI
Mesabi Range Community & Technical College	MN
Metropolitan State University	MN
Crowder College	MO
Northwest Missouri State University	MO
Tougaloo College	MS
University of Montana/ Montana Tech	MT

Appalachian State University	NC
Central Carolina Community College	NC
Fayetteville State University	NC
New Covenant Community Development Center	NC
Saint Augustine's College	NC
Creighton University	NE
Metropolitan Community College	NE
Nebraska Methodist College of Nursing & Allied Health	NE
University of Nebraska/ Lincoln	NE
Keene State College	NH
Ramapo College of New Jersey	NJ
State University of New Jersey/ Rutgers	NJ
New Mexico Institute of Mining & Technology	NM
University of New Mexico	NM
University of Nevada/ Las Vegas	NV
University of Nevada/ Reno	NV
Medaille College	NY
Monroe Community College	NY
State University of New York	NY
University of Rochester	NY
Cuyahoga Community College	OH
Kent State University	OH
Nationwide Children's Hospital	OH
Shawnee State University	OH
Stark State College of Technology	OH
University of Akron	OH
University of Toledo	OH
Northwestern Oklahoma State University	OK
Seminole State College	OK
Southeastern Oklahoma State University	OK
Indiana University of Pennsylvania	PA
LULAC National Educational Service Centers, Inc. (LNESC)	PA
Northwest Tri-County Intermediate/ Unit	PA
Pennsylvania State University	PA
Temple University	PA
The Trustees of the University of Pennsylvania	PA
Trident Technical College	SC
East Tennessee State University	TN
Tusculum College	TN
University of Tennessee/ Chattanooga	TN
University of Tennessee/ Knoxville	TN

Opportunity Resource Services	TX
Palo Alto College	TX
San Antonio College	TX
San Antonio College	TX
Southern Methodist University	TX
Texas Southern University	TX
Texas Wesleyan University	TX
The Salvation Army GA	TX
University of Texas/ Arlington	TX
University of Texas/ Arlington	TX
University of Texas/ Arlington	TX
University of Texas/ Rio Grande Valley	TX
West Texas A&M University	TX
Patrick Henry Community College	VA
Southwest Virginia Community College	VA
Evergreen State College (Clover Park)	WA
Evergreen State College (Tacoma)	WA
University of Washington	WA
Washington State University	WA
Marian University, Inc.	WI
Marquette University	WI
University of Wisconsin/ Green Bay	WI
University of Wisconsin/ Milwaukee	WI
University of Wyoming	WY

Schools Science Teachers and/or Principals Contacted

Seattle High Schools

Ballard
The Central School
Nathan Hale
Ingraham
Interagency
Lincoln
Middle College
Roosevelt
Skills Center
Cleveland
Franklin
Garfield
Nova
Rainier Beach
Chief Sealth International
Seattle World School
South Lake
West Seattle

Seattle Middle Schools
Jane Addams
Robert Eagle Staff
Eckstein
Hamilton International
McClure
Whitman
Denny
Aki Kurose
Madison
Meany
Mercer
Washington Middle School

Spokane Summer Programs Contacted
Mica Peak
Spokane Virtual Learning
Gonzaga Prep
Spokane Valley Tech

Local Middle and High Schools Contacted

Asotin Jr/Sr High School	WA
Colton Jr/Sr High School	WA
Clarkston High School	WA
Clarkston Lincoln Middle School	WA
GarPal Middle School (Garfield)	WA
GarPal High School (Palouse)	WA
Lewiston High School	ID
Lewiston Jenifer Jr. High	ID
Moscow Middle School	ID
Moscow High School	ID
Pullman Lincoln Middle School	WA
Pullman High School	WA
Potlatch Jr-Sr High School	WA
Troy Jr-Sr High School	ID
Lapwai Middle/High School	WA
Deary Jr/Sr High School	ID

Appendix B: Survey Instrument

Survey questions

Non-Content Based Questions for Middle and High School

Understanding Population:

1. How old are you?
2. What grade are you in?
3. What gender are you?

Factors:

How much time do you spend…

1. …watching TV per day?
a. 0 - 1 hour
b. 2 - 3 hours
c. 4 - 5 hours
d. 6+ hours
2. …using electronics (cell phone, iPad, etc.) per day?
    a. 0 - 1 hour
    b. 2 - 3 hours
    c. 4 - 5 hours
    d. 6+ hours
3. exercising per day?
    a. 0 - 1/2 hour
    b. 1/2 - 1 hour
    c. 1 - 2 hours
    d. 2+ hours
4. reading per day?
    a. 0 - 1/2 hour
    b. 1/2 - 1 hour
    c. 1 - 2 hours
    d. 2+ hours

Stigmas:

1. What do you think a scientist looks like?
2. What do you think makes a good scientist?
3. Who can become a scientist?

Academic Self-Efficacy (Q14 on survey):

1. I can finish homework assignments by deadlines.
    a. Very untrue
    b. Somewhat untrue
    c. Unsure

   d. Somewhat true
   e. Very true
2. I can study when there are other interesting things to do.
   a. Very untrue
   b. Somewhat untrue
   c. Unsure
   d. Somewhat true
   e. Very true
3. I can take good notes in class.
   a. Very untrue
   b. Somewhat untrue
   c. Unsure
   d. Somewhat true
   e. Very true
4. I can succeed on tests.
   a. Very untrue
   b. Somewhat untrue
   c. Unsure
   d. Somewhat true
   e. Very true
5. I can ask questions in class.
   a. Very untrue
   b. Somewhat untrue
   c. Unsure
   d. Somewhat true
   e. Very true
6. I am good at writing papers.
   a. Very untrue
   b. Somewhat untrue
   c. Unsure
   d. Somewhat true
   e. Very true
7. I am a very good student.
   a. Very untrue
   b. Somewhat untrue
   c. Unsure
   d. Somewhat true
   e. Very true
8. I usually do very well in school and at academic tasks.
   a. Very untrue
   b. Somewhat untrue
   c. Unsure
   d. Somewhat true
   e. Very true
9. I find my academic work interesting and absorbing.
   a. Very untrue

b. Somewhat untrue
c. Unsure
d. Somewhat true
e. Very true

10. I am very capable of succeeding.
    a. Very untrue
    b. Somewhat untrue
    c. Unsure
    d. Somewhat true
    e. Very true

Belongingness (Q15 on survey):

1. I can be myself at school.
    a. Almost never
    b. Sometimes
    c. Often
    d. Almost always
2. I feel like I don't belong at school.
    a. Almost never
    b. Sometimes
    c. Often
    d. Almost always
3. I have close relationships with my teachers and friends.
    a. Almost never
    b. Sometimes
    c. Often
    d. Almost always
4. I think that I am not involved in many activities at school.
    a. Almost never
    b. Sometimes
    c. Often
    d. Almost always
5. I feel myself excluded at school.
    a. Almost never
    b. Sometimes
    c. Often
    d. Almost always
6. I see myself as part of this school.
    a. Almost never
    b. Sometimes
    c. Often
    d. Almost always
7. I think people care about me at school.
    a. Almost never
    b. Sometimes
    c. Often

d. Almost always

Content Based Questions for Middle School and High School

Questions from information in: https://www.youtube.com/watch?v=DP62ogEZgkI

1. What is a traffic signal?
    a. *Electric traffic control device*
    b. The people who control traffic
    c. Cars at intersections
    d. A stop sign
    e. I don't know
2. What is an actuated signal?
    a. *A traffic signal activated by vehicles or pedestrians*
    b. A stop sign
    c. A traffic signal that has fixed cycles lengths
    d. Any traffic light
    e. I don't know
3. What is signal coordination?
    a. A button allowing pedestrians to activate the light
    b. *Traffic signals that connect with each other to optimize traffic flow*
    c. A traffic signal that has fixed cycle lengths
    d. A signal activated by a vehicle
    e. I don't know
4. What is a phase?
    a. *The amount of time a signal is a certain color*
    b. The area where a traffic signal is
    c. A city where a traffic signal is
    d. The number of cars that pass through a traffic signal
    e. I don't know
5. What is a traffic signal controller?
    a. *A box that is used to reprogram signals*
    b. A person who controls a traffic signal
    c. The button we press at a crosswalk
    d. The cars at a traffic signal
    e. I don't know
6. What is an urban area?
    a. *A highly populated area or city*
    b. A sparsely populated area or farmland
    c. A place where not many people drive
    d. A forested area
    e. I don't know
7. What is a rural area?

a. A sparsely populated area, farmland
b. A highly populated area, city
c. A place with a lot of houses
d. A place where people drive frequently
e. I don’t know

Video Related Questions

After this video: https://www.youtube.com/watch?v=ksTY7JeT78w

1. What surprised you about a transportation engineer?
2. Was there anything that interested you?

After this video: https://www.youtube.com/watch?v=DP62ogEZgkI

1. What type of area do you live in?
    a. Urban
    b. Rural
2. What surprised you about the video?

Appendix C: Recruitment

Outreach letter sent to Upward Bound Directors

Dear Upward Bound Director,

Greetings from WSU! I'm contacting you about an engineering research project for middle and high school students that I'm hoping you can share with your UB students. The goal of this project is to educate students about transportation engineering and pique their interest in further studies or career options in the field. We have set this up in Qualtrics and it is completely anonymous. We're offering students the chance to win $75 for participating in this project, which takes about 30-45 minutes to complete. With the data we compile, we hope to create a successful STEM curriculum for K12 students.

Please call me if you have any questions on my cell phone: **, and feel free to share this with other UB directors and personnel. Thank you in advance for your help! To read more about this project and to access the project/survey, you can visit https://tridurle.wsu.ed/TEP or click on the link below to access the survey directly.

https://wsu.co1.qualtrics.com/jfe/form/SV_aXYjYP6QzKu5jg1

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