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Framework for a Summer Experience based on Transformational Leadership and Constructivism (SumEx-TLC)

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The Construction Industry plays a critical role in the construction and maintenance of the national infrastructure. However, the industry faces numerous challenges, one of which is the labor shortage. One way to alleviate the challenge is to encourage high school students to pursue careers in construction industry programs. Historically, summer experiences have been utilized by educators to facilitate career choices among high school students. However, limited literature exists on the use of Transformational Leadership and Constructivism (TLC) for Construction Summer Experiences. Therefore, the study discusses the development, delivery, and assessment of the Construction of Transportation Infrastructure Academy – Summer Experience grounded on TLC theories. The targeted population of the study was the economically disadvantaged high school students in the inner cities. Four Key Performance Indicators (KPI) were used to assess the summer experience's effectiveness based on TLC. Utilizing an online survey at the end of the summer experience among the participating high school students, the study found that the participating students' perception of careers in the construction of the transportation industry improved considerably.

Key Words: Construction of Transportation Infrastructure, Summer Experience, Constructivism, Transformational Leadership.

Introduction and Background

Multiple sources in the literature indicate the need to construct and maintain existing infrastructure within the US (ASCE, 2017; CFR 2020) to meet the current and future societal demands and economic growth. The construction industry will play a critical role in the restrengthening of the national infrastructure. However, the construction industry faces numerous challenges, such as skilled labor shortages (Forbes, 2019), safety, low productivity (ENR, 2019; Quarles, 2019), aging of the workforce (BLS, 2015; Sokas et al., 2019), and others. Thus, indicating the existence of numerous externalities that impact the construction industry's ability to support the existing infrastructure's maintenance. Creating awareness among high school students about the construction and infrastructure industry, its importance, future opportunities, and career pathways can encourage them to join and be one way to stem some of the challenges faced.

Individual career choices are based on interests, perceptions, attitudes, and values (Hammack et al., 2015), and K-12 is where they are established (Bhattacharyya et al., 2011; George, 2006). Summer camps have been used by educators across numerous fields, including STEM, to encourage positive perception and facilitate career choices among high school students (Bhattacharyya et al., 2011; Hammack et al., 2015). The need for construction-related summer camps is critical as high school students negatively perceive the construction industry (Escamilla et al., 2016). Research indicates a perception issue among high school students influencing the construction industry's career choices (Escamilla et al., 2016). At the same time, Architecture, Engineering, and Construction (AEC) summer camps/experiences are conducted across the US universities. For example, Carrasquillo et al. (2017) depicted using information technology and programming in a two-week camp for high school students to promote construction careers. Mehany et al. (2019) depicted the impacts of summer experience on the perception changes for young females and, in the process, created higher awareness about professional careers in the construction industry. Further, multiple universities conduct AEC education-specific high school summer camps (Auburn, 2020; Texas A&M, 2020; Virginia Tech., 2020). At the same time, it is imperative to realize that learning pedagogies play a pivotal role in delivering summer camps and enhancing participants' experiences.

Numerous learning pedagogies exist and impact instructional delivery within a summer experience. Constructivism Learning Theory has been effectively utilized in science and mathematics (components of STEM), characterized with collaborative interactions adding informality to education, and supports the rebuilding of experiences that result in perceptions (Hendry, 1996). Some of the components of constructivism include "*eliciting prior knowledge (involving creating new knowledge in context of pre-existing knowledge), creating cognitive dissonance (involving assigning activities that challenge participants), applying knowledge with feedback (involving evaluation of new knowledge and modification of existing)*, and others" (UB, 2020) and can easily be applied within the realms of the summer experience. The theory also allows participants to collaborate and discover in a self-guided environment. Additionally, research indicates the use of pedagogy for altering students' perceptions (which, as per literature, is negative for construction), developing a more in-depth understanding among students of how things work, and generating an active learning environment (Tam, 2020). Given the learning theory's synergies and benefits, it was used to develop the summer experience in tandem with Transformational Leadership. Transformational Leadership involves "*inspiring followers to commit to a shared vision and goals, challenging them to be innovative problem solvers and developing followers' leadership capacity via coaching, mentoring, and provision of both challenge and support*" (Kramer, 2007), and has application within academia (Balwant, 2016). Given that the two concepts had numerous overlaps with applicability (academia), impacts, and target population (high school students), they were used in tandem. Additionally, no significant study could be found that discussed the implementation of construction infrastructure summer experiences based on Transformational Leadership and Constructivism (TLC).

Thus, the paper discusses the *development, delivery*, *and pilot-assessment* of the Construction of Transportation Infrastructure Academy – Summer Experience grounded on TLC theories.

Research Methodology

Since this research aims to fill the gap that currently exists on the theoretical framework to develop and implement summer experience, an exploratory mixed research method design was implemented (Clark et al. 2008). The mixed research method design was implemented in two phases: 1- Qualitative and 2- Quantitative. During the qualitative phase, a systematic literature review was conducted on the proposed framework's theoretical foundation, which enabled the development of the proposed framework. The qualitative method was used to conduct a semi-systematic literature review (resulting in gap identification for learning pedagogies), select learning pedagogies for the experience, identify collaborators, and develop partnerships. Also, an Intermodal Advisory Committee (IAC) was established that helped in the content validation and confirmation of Key Performance Indicators (KPI) that would assess the summer camp's success. Process maps were used to generate an overall project framework. Based on the framework, the summer experience was delivered and evaluated using the quantitative method. The quantitative method was an experimental design having a pre-test and post-test assessing the previously identified KPI's among the target population. The targeted population was the economically disadvantaged high school students that participated in the summer experience. The pre-test and post-test were measured through an online survey.

Results

Since the study discusses the *development, delivery*, *and pilot-assessment* of the Construction of Transportation Infrastructure Academy, the results are divided into three components: 1- Instrument and Summer Experience Development, 2- Instrument and Summer Experience Delivery, and 3- Instrument and Summer Experience Assessment.

Instrument and Summer Experience Development

The hands-on Construction of Transportation Infrastructure Academy focused on the construction of infrastructure for the three types of transportation (Land, Air, and Water) and its safety components, its content directly linked with the Texas Essential Knowledge and Skills (TEKS) in Science, Technology, Engineering and Math (STEM) as well as marketable "*Soft*" Skills. The hands-on summer experience was held at the University of Texas at San Antonio (UTSA) – Downtown Campus by the Professors of Department Construction Science, Institute for P-20 Initiative (UTSA), high school teachers, and Intermodal Advisory Council (IAC). The specific, measurable learning objective of the summer experience focused on developing hard and soft skills required for a successful career in the construction and transportation industry (Table 1).

Table 1. Summer Camp Student Learning Objectives

Transportation types, safety, and infrastructure	Applied STEM TEKS	Marketable "Soft" Skills
• Determine the components of the rail transportation system • Identify highway design considerations • Outline air transportation elements • Describe deep-sea transportation freight and passenger • Explain inter-costal waterways	• Use physics (TEKS 112.39) to design bridges • Develop 3D Models (TEK 126.43) to communicate transportation infrastructure • Apply geometry concepts (TEKS 111.41) to quantify materials needed to build transportation infrastructure	• Identify university student expectations & transportation career opportunities • Demonstrate teamwork • Communicate using effective methods • Apply consensus-building techniques

A close partnership between the school district and the Department of Construction Science (UTSA) facilitated the summer experience and was designed to be implemented in five phases (Figure 1). The summer experience was designed to be deployed in a week with daily activities and a celebration/showcase on Friday.

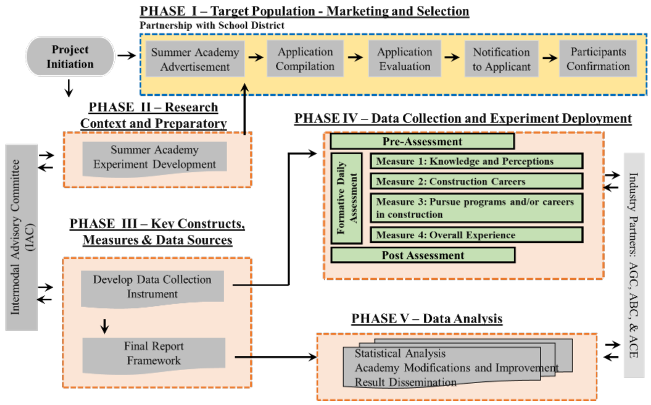

Figure 1. Summer Experience Implementation

Phase I- Target Population Selection

The study's targeted population was economically disadvantaged high school students in San Antonio, and the research team provided the Independent School District (ISD) with the marketing materials. Advertisement pamphlets were posted in the common areas, and students were emailed about the opportunity. All applications were compiled and evaluated by the participating high school principal's office. The high school principal's office was allowed to select up to 24 students to be the participants. Top applicants were selected based on academic performance and essay. The ISD also had the opportunity to choose two teachers to collaborate with the research team.

Phase II – Research Context and Preparatory Work

Researchers and Intermodal Advisory Committee (IAC) met to finalize the draft activities and the summer camp assessment to have a meaningful and lasting effect on the participating high school students. The IAC confirmed the KPI that would assess the instrument and summer camp's success.

Phase III – Develop Key Constructs and Data Sources

The data source was multiple direct assessments of participants. The assessments were conducted at the beginning of the summer experience (pre-assessment), daily through the summer experience, and post-assessment at the end of the summer experience.

Phase IV-- Data Collection and Summer Experience Deployment

The research team and partners deployed the summer experience using the curriculum (Table 2). Hands-on activities were included in every session, and the session details have been discussed in subsequent sections. All data were initially collected online via Qualtrics. All collected information was designed to maintain the confidentiality of the student respondent.

Phase V – Data Analysis

All data collected from the participating students and post-assessments were analyzed, including the assessment of KPIs using statistical analysis.

Instrument and Summer Experience Delivery

Session Details
The instrument included twenty-one sessions with sessions focused on developing soft marketable (nine sessions) skills hard skills (twelve sessions) supporting the STEM-TEKS (Table 2). The soft marketable skills sessions are highlighted in blue, and the hard skills sessions are highlighted in orange and gray (Table 2). Four tenets of TLC formed the basis of the sessions. For Constructivism, the tenants supporting the developed instrument included *Active Learning, Learning-by-doing, Scaffolded Learning,* and *Collaboratio*n (Harasim, 2017). For Transformational Leadership, the tenants supporting the developed instrument included *Idealized Influence, Inspirational Motivation, Intellectual Stimulation,* and *Individualized Consideration* (Bass & Riggio, 2006). All instrument sessions had the tenets of TLC, and the instrument sessions were designed so that most of the sessions were approximately 90 minutes. For each session, the first 15/20 minutes were allocated to the theory discussion, and the remaining time was devoted to hands-on activities that supported the discussed theory. The subsequent section discussed each of the sessions designed for the summer experience.

Table 2. Hands-on Activities Summer Experience

Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:30 - 8:55 AM	Check-In & Breakfast	Daily Sign-in and Breakfast			
9:00 - 10:30 AM	**Jump** *Institute Overview, Icebreaker & Project*	**Say it** *Communication*	**Roadrunner** Leadership	**Achieve** *Univ. Academic Expectations*	Field Trip **Let's Travel** Texas Transportation Museum
10:30 - 10:40 AM	*Morning Break*				
10:45 - 12:15 PM	**Make it work** *Teamwork*	Land **May the Force** *Safe Highway Design (TEK 112.39)*	**Agree** *Consensus Building*	**Make it Happen** *Transportation Career Opportunities*	Field Trip **Let's Travel** Texas Transportation Museum
12:15 - 12:55 PM	*Lunch (Provided to all participants at no cost)*				
1:00 - 2:30 PM	Air/Water **Flying Rapids** *Air & Inter-Costal Infrastructure* (TEK 111.41)	Air/Water/ Land **Transport** *Transportation Inf. 3D Mod. (TEK 126.43)*	Air/Water/ Land **Survive** *Transportation Safety*	Air/Water/ Land **BridgeIt** Construction of Transportation Infrastructure	Air **From the Sky** *Air Transportation Element (TEK 112.39)*
2:30 - 2:40 PM	*Afternoon Break*				
2:45 - 4:00 PM	Air/Water **Flying Rapids** *Air & Inter-Costal Infrastructure* (TEK 111.41)	Air/Water/ Land **Transport** *Transportation Inf. 3D Mod. (TEK 126.43)*	Air/Water/ Land **Plan** *Design Transportation System*	Air/Water/ Land **Intermodal** Synergy among multiple of mode transportation	**Prepare** *Communication*
4:00 - 4:10 PM	*End of the Day Assessments and Sign-Out*				
4:30 - 6:00 PM					**Succeed** *Celebration Showcase, and Dinner*

Session 1.1 – Jump. The session provided an overview of the summer experience, introduced expectations and objectives of the summer experience, as well as a brief overview of the Texas Department of Transportation (TxDOT), Federal Highway Administration (FHWA), and the Construction Program to discuss individual goals and career opportunities. After the initial exercise, an ice-breaker with "Bingo" was played with the students to let students introduce themselves and help them identify teammates for the remainder of the sessions.

Session 1.2 - Make it work. This session introduced the concept of "*Teamwork,*" followed by two interactive games supporting the concepts. The first twenty minutes provided an infrastructure industry overview. The remaining seventy minutes were allocated to playing two games (Card Pyramid and the Air Structure) that emphasized the importance of working collaboratively and consensus decisions that are integral components of teamwork.

Session 1.3 - Flying Rapids. This session educated the high school students about infrastructures for air and water transportation and construction equipment's role to build it (tied to geometry STEM - TEKS 111.41). Discussion on the different infrastructure types needed to make water and air transportation possible started the session. The students were given access to an artificially created site and asked to calculate the quantities of dirt to be excavated. The students were then provided access to the remote-controlled trucks and front loaders to estimate the number of truckloads to move the dirt. All students were provided twenty minutes to plan the extraction and route that they would take. The students recorded their estimated dirt quantity, the number of truckloads, and time in the provided sheet before the end of the session.

Session 2.1 - Say it. This session introduced the concept of "*Communication,*" including: the importance of communication, skills associated with effective communication, listening generously, speaking straight, and others. Two interactive games reinforced the concepts:

1- Spot the corner where students with colored dots on their forehead must align themselves based on the color of the dot using non-verbal cues;
2- Picture it involved competing teams to allow each team member to draw a card with a word related to a transportation mode with the remaining team members guessing the word on the card based on non-verbal clues.

Session 2.2 - May the Force. This session discussed infrastructures for land transportation, including roads, bridges, bridge types, loads that impact road/bridge design, and explain the importance of various loads and forces. The content was built upon the physics TEKS 112.39 to design bridges. The students were also exposed to computer simulations that reinforced the concept.

Session 2.3 - Transport. This session's goal was to discuss transportation infrastructure construction using 3D technology and build upon the Technology TEKS-126.43. The students were given the option to select a transportation infrastructure (as their final project) that supports air, water, or land movement of people and/or freight. Once the students selected their project, the design constraints were provided. The constraints included allowable dimensions, usable materials, and others. Based on the constraints provided, the students: 1- Designed the project individually, 2- Modeled project using the 3D Software, and 3- 3D printed model of the transportation infrastructure.

Session 3.1 - Roadrunner. This session introduced "*Leadership,*" followed by the students' interactive games that supported the short discussion. The first game, Minefield, was completed in groups of 7-10 students. The team leader (not-blindfolded) was responsible for navigating through the minefield without triggering the mines. The second game, Build the Tower, allowed the students to demonstrate their understanding of physics TEKS 112.39 and maths by constructing a 3' tall structurally stable tower using wooden skewers, coffee stirrers, marshmallows, and tape.

Session 3.2 - Agree. This session introduced "*Consensus building,*" followed by a game played by the students that supported the concepts. The discussion explained the concept of consensus building within a team environment. After which, the students played the "*Consensus Ropes,*" where the taught concepts were implemented. After the consensus ropes game, the participants self-selected teams and obtained a consensus on which transportation infrastructure to build (Air, Water, or Land).

Session 3.3 - Survive. The session exposed the participating students to the safety associated with the infrastructure-construction equipment's operation. Before the session, all students were provided safety vests, hard hats, and eye protection glasses. The students learned the safety procedures associated with the equipment, taught by the shop supervisor and an assistant. The students were exposed to computer simulation, where the students realized the economic impacts of site-safety.

Session 3.4 - Plan. The session's goal was to develop a construction plan for a 3'x5' scaled model of the air, water, or land transportation infrastructure. The objective of the session was to use the "*Soft*" and "*Transportation Technical*" skills learned in the previous sessions to create a site that not only demarcates the three infrastructure components but also connects them (multimodal). All participants came together as one team and identified how their project connected on the provided site. The output included a schematic site plan that was used to identify the layout of infrastructure components.

Session 4.1 - Achieve. This session introduced "*Academic Expectation*" at the post-secondary education level. This session started with a panel discussion led by the P-20 Initiative and composed of current university students, staff, and construction faculty. The panel explained what participating students could expect during education at the university and various available resources for success. The activity was followed by the "*Scavenger Hunt.*"

Session 4.2 - Make it Happen. This session introduced the students to the multiple career path opportunities in the transportation industry. This session started with a ten-minute discussion linking the students' activities in the Summer Institute and the transportation job profiles.

Session 4.3 - Bridgeit. This session required the students to construct the team's transportation infrastructure project (Air, Water, or Land). Relevant materials for the project's construction were provided, and the students constructed their team project. The team adhered to the agreed-upon constraints created during the development of the construction plan during Session 3.4.

Session 4.4 - Intermodal. The teams compiled the constructed infrastructure project (Air, Water, and Land) on a macro plan for a 3'x5' scaled model in the session. The goal was to ensure that the students understood the synergies generated by the multimodality of transportation infrastructure.

Session 5.1 - Let's Travel. This session was a site visit to the "San Antonio Transportation Museum" to depict the infrastructure and equipment's evolution. The two-hour site-visit provided insight into the city's historical infrastructure development and enabled a better understanding of the principles supporting mass transportation.

Session 5.2 - From the Sky. The session reinforced the concepts associated with innovation. The students controlled a drone, rotated the drone along different transportation infrastructure models, and took pictures of the buildings. At the end of the session, each student had drone images of the models.

Session 5.3 - Prepare. The session allowed students to prepare for the team presentations conducted during Session 5.4 (Succeed). Each team had 5 minutes to share: 1- Perceptions about the transportation career pathways, 2- Progress on the design-planning-construction of a transportation infrastructure project, 3-Highlights of the most enjoyable sessions and lessons learned.

Session 5.4 - Succeed. The invite-only session showcased the participating students' work to the parents, school authorities, IAC members, and other stakeholders associated with the summer institute. The students had the opportunity to present their project as a team to the audience, share experiences, and discuss concepts learned during the summer camp.

Instrument and Summer Experience Assessment

During the Phase II of the first component (Instrument and Summer Experience Development), IAC confirmed KPI's that assessed the instrument and summer camp's success. Four KPI's were assessed and discussed in the study. All assessments were conducted online utilizing Qualtrics. Assessments were conducted before the summer experience (pre-test) to assess the baseline and at the end of the summer camp (post-test) in the following categories, to assess its effectiveness:

1- Awareness about career choices in Construction of Transportation Infrastructure (KPI_1)
2- Likelihood to select a career in Construction of Transportation Infrastructure (KPI_2)
3- Likelihood to enroll in Construction-related courses in higher education (KPI_3)
4- Likelihood to enroll in Transportation infrastructure-related courses (KPI_4)

As depicted (Figure 2), all KPI observed considerable improvements with indications of *higher awareness in career choices* (KPI_1) and *likelihood to select a career in Construction of Transportation Infrastructure* (KPI_2). The respondents also demonstrated *a higher enrollment likelihood in courses associated with construction* (KPI_3) and *transportation infrastructure* (KPI_4).

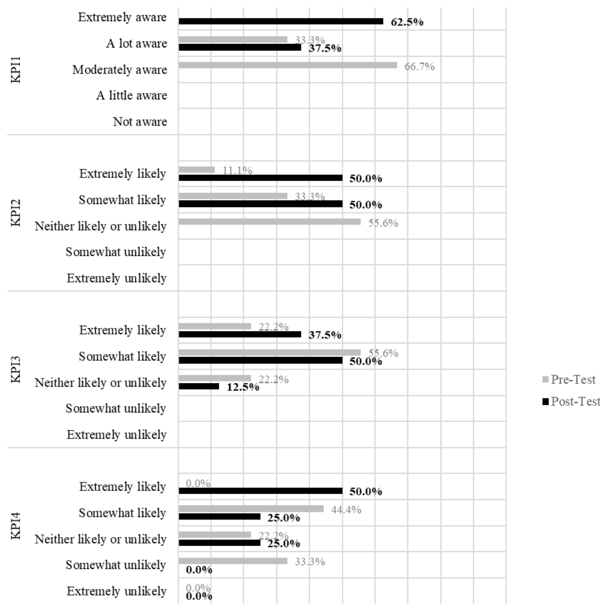

Figure 2: Respondent assessment of the KPI based on the Summer Experience (n =9)

Summary / Conclusion

The development, delivery, and pilot-assessment of the Construction of Transportation Infrastructure Academy – Summer Experience grounded on TLC theories were discussed in the article. The framework utilized an exploratory mixed research method design, with the first part of the research focusing on the framework development. Process maps were used to generate an overall project framework. The developed framework had five phases. The first three phases focused on selecting the target population (economically disadvantaged high school students in the inner cities), obtaining approval from the IAC, and developing constructs for the study. The fourth phase involved the pilot testing of the instrument for the summer experience through the targeted population. The developed instrument had twenty-one sessions, with nine sessions focused on developing soft marketable skills and remaining focused on the TEKS's hard skills. All sessions within the developed instrument had the tenets of TLC. Four KPI's were used to assess the effectiveness of summer experiences based on TLC. Pre-test and post-test were used to assess the identified KPI's among the respondents. The assessment was conducted utilizing a survey at the end of the summer experience. The assessment indicated participating students' perception of careers in the construction and transportation industry improved considerably. However, given the small participant size in the pilot study, an argument for generalizability or summer experience success needs to be further validated in the future. Future research aims to assess the validity and reliability of the framework for a broader population involving women, minorities, and economically disadvantaged students. Another aspect of future research will be to ascertain the length of time for which the student perception changes (measured by KPI-awareness and enrolment likelihood) lasts and the point at which the intervention efforts tend to wane.

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