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MarTREC
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Exposure to STEM: Diversity in Maritime Transportation

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Richard A. Coffman, PhD, PE, PLS
Department of Civil Engineering
University of Arkansas
Fayetteville, AR

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University of Arkansas
4190 Bell Engineering Center
Fayetteville, AR 72701
479-575-6021

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1. ABSTRACT

Although the 1954 U.S. Supreme Court decision in the case of Brown vs. Board of Education declared state laws establishing segregated public schools unconstitutional, in 1957 Arkansas Governor Orval Faubus tried to prevent nine African American students from attending school at Little Rock Central High School (LRCHS). Faubus' attempt to block access to the students, using the Arkansas National Guard, resulted in President Eisenhower using soldiers from the 101st Airborne Division from Fort Campbell, Kentucky, to escort the students into the high school. Even though all students, regardless of race, can now attend public schools, segregation in a different form is still very evident when considering Advanced Placement (AP) classes. The lack of students from underrepresented minorities is especially evident in AP classes affiliated with the Science, Engineering, Technology, and Mathematics (STEM) disciplines.

The goal of this education and workforce development project was to develop an educational/mentoring/advising model to open doors to all students, regardless of socio-economic background, who want to go on to careers in fields related to maritime and multimodal transportation. This goal was accomplished through knowledge transfer and mentoring partnerships established at the following institutions: 1) Village of Promise (VP) in Huntsville, Alabama, 2) LRCHS in Little Rock, Arkansas, 3) Philander Smith College (PSC) in Little Rock, Arkansas, and 4) the University of Arkansas (UA) in Fayetteville, Arkansas. The proposed approach for this project was similar to the successful Harlem Children's Zone (HCZ) pipeline model that is shown in Figure 1.

Figure 1. HCZ pipeline model (HCZ Website, 2018).

The proposed work included visits to the respective institutions and field trips/visits of the participants to local maritime navigation structures. Visits to Lock and Dam (L&D) structures like the Murray L&D in Little Rock, Arkansas and the Guntersville L&D in Huntsville, Alabama, took place on April 2, 2019, and September 25, 2019, respectively. These field trips bolstered the information that was presented to the students on the history and present-day use of maritime navigation and hands-on model-scale dam creation demonstrations.

The application of the HCZ model for STEM is promising and may contribute to the development of a diverse workforce for maritime transportation. Evidence exists that the HCZ model has worked for the city of Harlem. VP, a participating partner institution, and other locations across the country have successfully implemented the HCZ model. In a similar fashion, education and workforce development was successfully achieved by blending existing programs at each of the associated institutions (UA, PSC, LRCHS, VP). Thus, students from underrepresented minorities, with STEM knowledge, were exposed to maritime principles and are now more aware of workforce opportunities within the maritime and multimodal fields.

2. PROJECT DESCRIPTION

The project background, motivation, scope, and contribution are described in this section. Specifically, the background is discussed in Section 2.1, the motivation is discussed in Section 2.2, the scope is discussed in Section 2.3, and the contribution is discussed in Section 2.4. The methods (Section 3), results (Section 4), impacts (Section 5), recommendations and conclusions (Section 6) are presented in the respective forthcoming sections.

2.1. Project Background

Under the direction of Geoffrey Canada, in 1970, the HCZ (initially identified as Rheedlen) established a model to change the culture of a 24-block area of Harlem. Specifically, what began as a truancy prevention program has morphed into a system in which all members of the community are focused on the success of one another. The program has evolved from serving Harlem through one community center to encompassing more than 100 square blocks of Harlem and serving more than 10,000 children and 7,400 adults. The FY 2017 budget for the agency was over $100 million. Under the visionary leadership of our President and CEO, Geoffrey Canada, HCZ continues to offer innovative and efficiently run programs that are aimed at doing nothing less than breaking the cycle of generational poverty for the thousands of children and families it serves. The VP in Huntsville, Alabama, is an offshoot of the HCZ. VP was selected as a partner institution for this project because of geographical proximity: 1) it is the closest HCZ offshoot program to the UA and 2) it is situated 30-miles from the Guntersville Lock and Dam. Likewise, LRCHS was chosen for this project because of 1) the close geographical proximity of LRCHS to the UA and the Murray Lock and Dam and 2) the historical significance of LRCHS. Finally, PSC was selected because of the close geographical proximity of PSC to the UA, LRCHS, and the Murray Lock and Dam.

The most effective way to impact future college students and professionals is to develop relationships with them early in their educational life. To change the lack of participation of underrepresented groups in high-school and college STEM, K-12 students were exposed to STEM through 1) hand-on scale models, 2) presentations, and 3) field trips to local lock and dam structures. A mentoring program was preliminarily established and implemented through multiple site visits by the various teachers and students. The students and faculty were made aware of the need for maritime infrastructure and the current condition of inland navigation infrastructure.

2.2. Motivation

A variety of approaches have been undertaken in the academic and educational communities over the past few decades to improve the recruitment and retention of underrepresented minority students into STEM degree programs. As described below, in this section, analysis of the outcomes (graduation rates, retention rates, student surveys) from many of these programs points to several successful initiatives and strategies.

Two-year colleges are an increasingly fertile recruitment ground for underrepresented minorities pursuing engineering degrees. From 1996-2000, 44 percent of African Americans and 51 percent of Hispanics had attended a two-year or community college before completing a STEM degree (Tsapogas, 2004). Students have been eager to complete an associates degree from a two-year college in concert with a subsequent engineering degree from a cooperating four-year university. Dr. Coffman, the PI for this project, went to a community college prior to completing his Bachelor of Science in Civil Engineering at a four-year institution, so he was familiar with the success of this two-year strategy.

A large body of research concurs that high levels of student involvement with faculty, in organizations, and with other students correlate with success in retention and graduation (Astin, 1985). Unfortunately, underrepresented minority students have historically had less interaction with faculty and other students than non-minority students (Hackett and Martin, 1988; Anderson-Rowland et al., 2000). Emphasizing high quality interaction between faculty and minority students is essential for retention. These interactions can, and should, include mentoring relationships, travel to conferences and professional activities, and undergraduate research. Julia Loshelder, an undergraduate student within the Department of Civil Engineering at the University of Arkansas, and Juan Martinez and Anh Tran, graduate students within the Department of Civil Engineering at the University of Arkansas, had the opportunity to benefit from mentoring relationships with Dr. Coffman during the duration of this project. In addition to interaction through undergraduate and graduate research, each of these students participated in conference and field trip travel.

2.3. Scope

The scope of the project included interaction between various entities to stimulate the participation of underrepresented students in STEM and within maritime transportation. Underrepresented groups at LRCHS were identified by contacting Mellissa Donham, the STEM club advisor, at LRCHS. Although it was intended for LRCHS students to be recruited to participate in a mentor/mentee arrangement where the LRCHS students will serve as a mentor to students at VP and be a mentee of a student at PSC, this was not accomplished during the short duration of the project. Likewise, although it was intended for the students at PSC to be recruited to the UA through the existing programs at the UA and PSC: the George Washington Carver Research Program (GWCRP, https://carver.uark.edu/), the Engineering Career Awareness Program (ECAP, https://ecap.uark.edu/) programs, and the 3/2 Engineering Program

(3/2EP, https://www.philander.edu/dual-degree-programs), this was not accomplished during the short duration of the project. Instead, this year-long project planted seeds of collaboration between VP, LRCHS, PSC, and UA to allow underrepresented students to transition and gain confidence along the mentee/mentor pipeline.

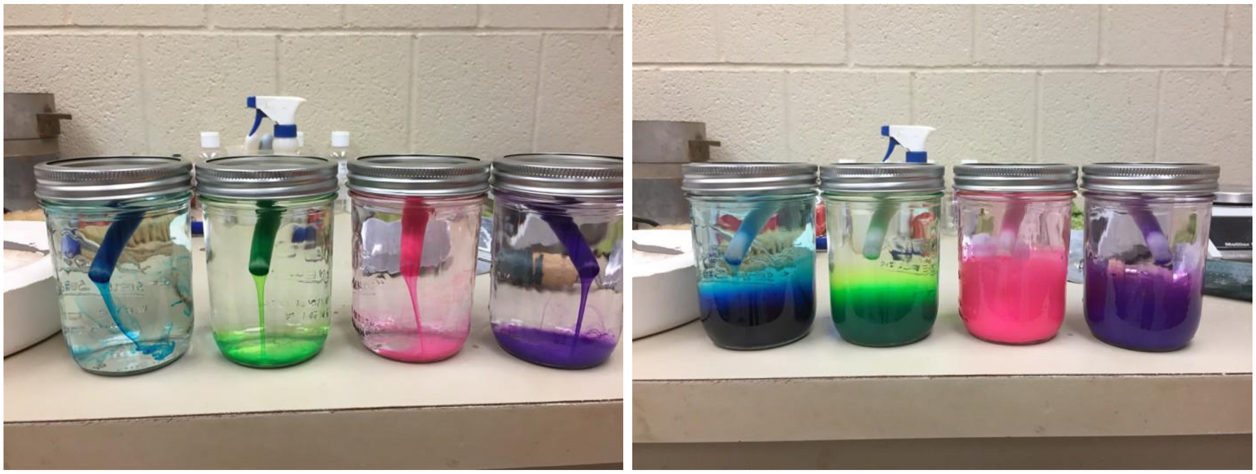
Based on the reviewer feedback that was provided in the full-proposal invitation for this project, the PI was asked to look into the e-STEM program in Little Rock. As per the e-STEM mission statement (e-STEM Website, 2018), the focus of e-STEM in Little Rock is to "develop students who are critical thinkers, problem solvers and collaborative members of a learning community and society." Based on this mission statement and discussions with Dr. Phillip Blake, the engineering, physics, and computer programming instructor at e-STEM, the focus of e-STEM is not specifically on recruiting/retaining students from underrepresented minorities in STEM. Two trips to Little Rock were devoted to meeting with Dr. Blake, at e-STEM, to discuss the e-STEM curriculum and to determine possible collaborations related to this maritime transportation project. Future potential of collaboration is evident.

3. METHODOLOGICAL APPROACH

3.1. Soil Fluorescence

Kaolinite clay (Kao-White S, Thiele Kaolinite, Sandersville, Georgia), a white powered clay, was used to show how clay changes when infiltrated by water. First grade through fourth grade students at Butterfield Elementary School in Fayetteville, Arkansas were provided with Kaolinite, water, and highlighter fluid. The soil was initially mixed with water only and the students held the soil/water mixtures under a black light. No changes in the soil were observed. Highlighter fluid was then added to each of the soil/water mixtures and the students again held the soil under a black light to see how the highlighter fluid infiltrates through the soil. The students enjoyed seeing the highlighter fluid in the soil by means of the blacklight. Understanding of this infiltration concept is needed, as water commonly permeates through the soil and rock surrounding many lock and dam structures which results in required maintenance at the lock and dam structures.

For this learning module, each student was provided with 25 gram of clay, 25 grams of water, and five (5) grams of highlighter fluid in separate containers. Eight (8) ounce cups were used to hold the solutions and the solutions were mixed with wooden popsicle sticks. Prior to the demonstration, the milking of highlighter fluid was accomplished by placing highlighter cartridges into Kerr jars for 24-hours (Figure 2).



(a) (b)

Figure 2. Photographs of highlighter cartridges in bell jars, a) immediately after placement of the cartridge into the Kerr jar, and b) after the cartridge has been in the Kerr jar for 24 hours.

3.2. Scale-model barge / scale-model lock and gate

Computer programming was proposed to be discussed during Little Rock Trip 4. Computer programming was discussed with Dr. Swaid at PSC during Little Rock Trip 4 on August 12, 2019, but the concepts were not discussed with the students at PSC or LRCHS. The concepts were not discussed for two reasons. 1) Most of the PSC students were not back on campus following the summer break. 2) The proposed small-scale lock and dam, created using acrylic walls, was not constructed due to similar small-scale lock and dams being constructed out of wood for the MarTREC GirlTREC outreach. The small-scale acrylic lock and dam was to be controlled using computer coding and robotics. Because the small-scale acrylic lock and dam was not created, no computer coding and robotics were necessary. Instead a small-scale panel dam was constructed using a fish tank (described in detail in Section 3.3) and the concepts of dam maintenance/patching were demonstrated through hands-on demonstrations.

3.3. Dam Model Using Bentonite Clay Seal

Small-scale plastic panel dams were constructed using 0.8 gallon Imagitarium Betta Fish dual habitat fish tanks that were purchased from Petco (Figure 3). These small-scale dams were initially used for the GirlTREC outreach efforts (4th and 5th graders) on July 9, 2019, then were reused for the Butterfield Elementary School outreach efforts (1st-4th graders) on September 9, 2019, and then were reused again for the Village of Promise

Figure 3. Betta fish dual habitat fish tank, obtained from Petco, and used as a small-scale panel dam (Petco, 2019).

outreach efforts (5th graders) on September 25, 2019. Groups of two to four students were each provided with a fish tank and asked to fill one side of the fish tank and observe what happened. While filling the fish tank, the water that was being poured into one side of the fish tank seeped under and around the plastic panel that was located in the middle of the fish tank until the water level on both sides of the fish tank was in equilibrium.

After the students identified the problem with the small-scale plastic panel dams, each group of students was provided with 15 grams of sodium bentonite (No. 8 Enviroplug, Wyo-Ben, Billings, Montana) and instructed to place the bentonite around the outside edge of the plastic panel. The students were also provided with a squirt bottle and told to slightly wet and smear the bentonite that was placed on the edges of the middle panel on the downstream side to develop a clay seal between the fish tank walls and the fish tank middle panel. Following hydration and smearing of the bentonite, the students were again requested to pour water into the upstream side of the small-scale plastic panel dam and observe the water level in the fish tank. The seal created by the bentonite prevented water from seeping around the middle plastic panel and enabled a hydraulic head from impounded water to be developed. If the seepage barrier was constructed properly, the water difference within the fish tank was equal to the height of the fish tank.

3.4. Murray Lock and Dam Visit

A field trip to Murray Lock and Dam, located in Little Rock, Arkansas, was facilitated on April 2, 2019. The field trip consisted of brief presentations by Dr. Coffman and graduate student Anh Tran to the students of the LRCHS STEM Club followed by 1) the students traveling from LRCHS to Murray Lock and Dam via school bus, 2) a walking tour of Murray Lock and Dam, 3) lunch in La Harpe View Park, and 4) the students traveling back to LRCHS via school bus. For completeness, the points of contact for the respective agencies that participated in the lock and dam tour are provided in Table 1. A second tour of the Murray Lock and Dam with students from the Little Rock Central High School AVID program was attempted but was not able to be arranged due to scheduling constraints.

Table 1. Points of contact for the Murray Lock and Dam Tour.

Name	Affiliation	Contact
Nancy Rousseau	LRCHS	501-447-1400 / nancy.rousseau@lrsd.org
Melissa Donham	LRCHS	501-447-1400 / Melissa.donham@lrsd.org
Tracy To	LRCHS	501-447-1400 / tracy.to@lrsd.org
Stacey McAdoo	LRCHS	501-447-1400 / stacy.mcadoo@lrsd.org
Samar Swaid	PSC	501-370-5334 / sswaid@philander.edu
Eric Gillespie	USACE	501-663-1997 / eric.a.gillespie@usace.army.mil
James McKinney	USACE	501-324-5096 / james.mckinnie@usace.army.mil

3.5. Guntersville Lock and Dam Visit

A field trip to Guntersville Lock and Dam, located in Guntersville, Alabama, was facilitated on September 25, 2019. As previously mentioned, the fifth-grade students at the

Village of Promise were provided with a hands-on demonstration of a panel dam, using the fish tanks and bentonite, that were described in Section 3.3, prior to going on the field trip to the dam. Following the demonstration, the students and chaperons traveled from VP to Guntersville Lock and Dam via a van that driven by Dr. Coffman. Upon arrival at the Guntersville Lock, the students observed the front six containers of a barge that was being moved through the lock. The student were then able to witness the first six containers of the barge tie off to the upstream wall, the upstream lock gate close , the lock chamber dewater, the downstream lock gate open, the rear six containers of the barge and the towboat move into the lock, the downstream lock gate close, the chamber fill, and the upstream lock gate open. After observing the operation of the lock, the students had lunch at the picnic shelter on the North shore of the lock and dam.

Following lunch, the students and chaperons drove for forty-five minutes to arrive at to the South shore of Guntersville dam. This forty-five-minute drive could have been alleviated by walking across the dam, but permission was not provided for the students and chaperons to walk across the dam. Upon arrival at the South shore of the dam, the students and chaperons toured the hydroelectric plant visited with the Tennessee Valley Authority personnel that operate the hydroelectric plant. Chip Troy, the Guntersville Hydro Plant Manager, provided a brief explanation of the Tennessee Valley Authority and the rational for the lock and dam system on the Tennessee River. The students were able to see the four electric turbines, the overhead cranes, and the gates that are opened or closed to control the amount of water to the turbines and to control the amount of flow along the river. For completeness, the points of contact for the respective agencies that participated in the lock and dam tour are provided in Table 2. McCurry Van and Car Rentals is specifically mentioned because this was the only agency in Huntsville that rented 15-passenger vans; this agency will be required for future field trips.

Table 2. Points of contact for the Guntersville Lock and Dam Tour.

Name	Affiliation	Contact
Valerie Hampton	VP	256-536-8052 / vhampton@villagepromise.com
Saadia Gauthier	VP	256-536-8052 / sgauthiervop@gmail.com
Ryan Johnson	USACE	256-582-3263 / ryan.p.johnson@usace.army.mil
Scott Fiedler	TVA	423-751-7883 / safiedler@tva.gov
Chip Troy	TVA	256-571-4321 /
Vanessa Amber	McCurry	256-713-0573 / vamber.mmc@yahoo.com

4. RESULTS/FINDINGS

4.1. Soil Fluorescence

Photographs of the University of Arkansas student mentors and the Butterfield Elementary Science Club students are provided in this section. As shown in the photographs (Figures 4 and 5), the students followed the instructions provided to them by the mentors and had a good time learning about clayey soils and learning about STEM fields. As shown in Figure

4, Julia Loshelder, an undergraduate student within the Department of Civil Engineering at the University of Arkansas, was very instrumental in encouraging and assisting the female students.

(a) (b)

Figure 4. Mentor Julia Loshelder helps students at Butterfield Elementary School to see soil fluorescing after the soil has been mixed with highlighter fluid.

Figure 5. Photograph of the Butterfield Elementary School students and University of Arkansas mentors as part of the Butterfield Elementary Science Club demonstration on fluorescent soils.

Mentors include: (back row) Dr. Richard Coffman, Juan Martinez, Johnathan Blanchard, Sean Salazar, Julia Loshelder, Anh Tran, and (middle) Esteban Miranda.

4.2. Scale-model barge / scale-model lock and gate

A line diagram was developed for the electronics to control the motors of the barge and gates, and time-of-flight laser scanners to provide servo-control of the barge (Figure 6). The parts that were used and programmed included: a Raspberry Pi Zero WH, two 28BYJ-48 5V 4 phase stepper motors acquired from Amazon, a Texas Instruments L293D stepper motor driver, an Adafruit VL53LOX time-of-flight sensor, an Adafruit V6180LOX tim[redacted] Adafruit TCA9548A I2C multiplexer. As previously mentioned, the ba[redacted] not constructed, but the controllers for the barge and lock and dam were programmed.

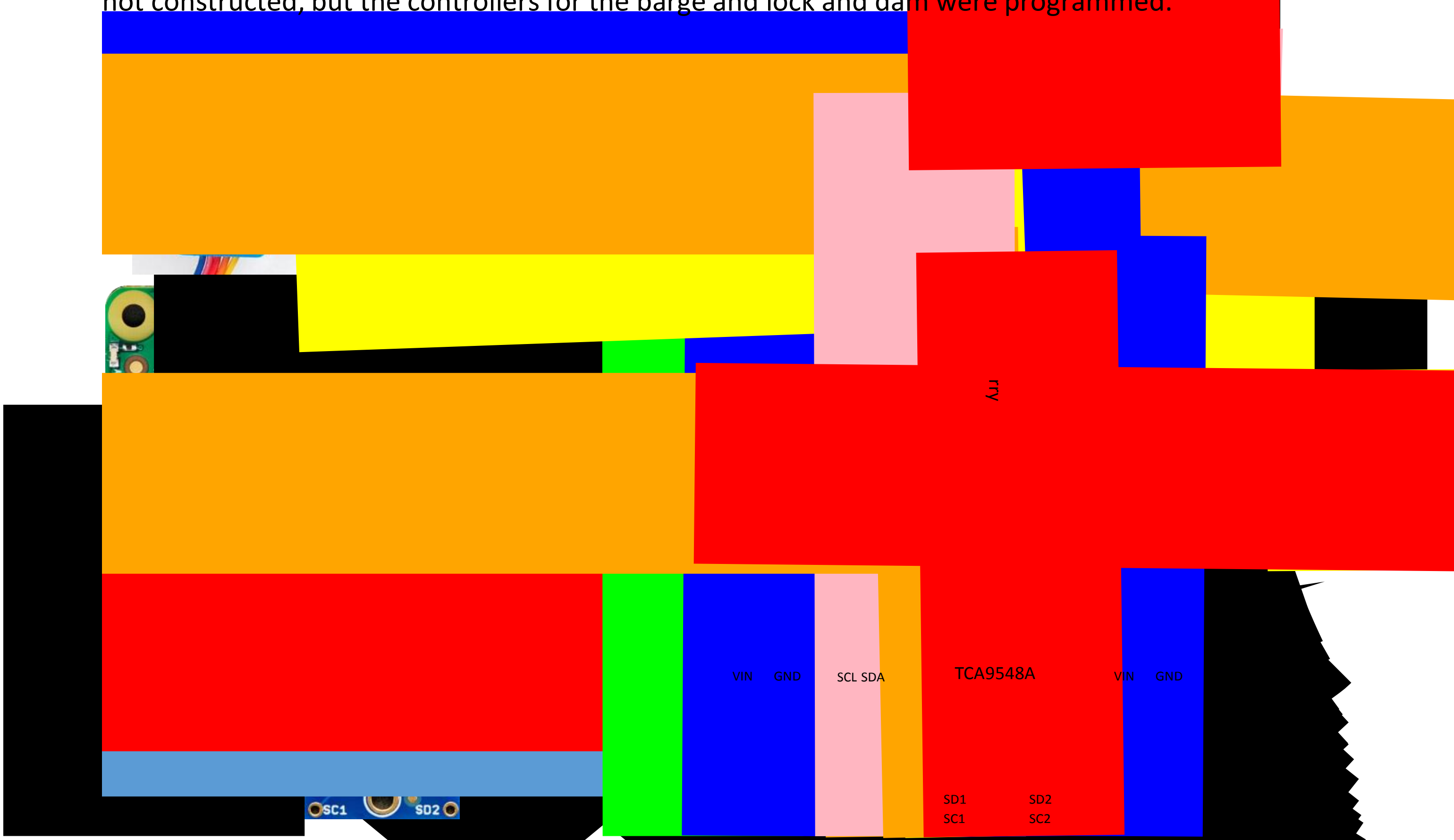


Figure 6. Photographs an... m of th... to con... the scale-model lock and gat...

4.3. Dam Model Using Bentonite Clay Seal

The plastic panel dam, that was constructed using the fish tank that was described in Section 3.3, was used for three outreach projects. Photographs taken during each of the outreach projects are provided in this section for completeness. The first outreach project that used the plastic panel dams was the GirlTREC summer program on July 9, 2019 (Figures 7 and 8). The second program to use the plastic panel dams was the Butterfield Elementary Science Club on September 9, 2019 (Figures 9 and 10). Because of the age difference in the students at

Butterfield, older students were paired with younger students; the plastic panel dam may have been too advanced for some of the first graders. The third program to use the plastic panel dams was the Village of Promise on September 25, 2019 (Figure 11). Fifth graders are an ideal target audience.

Figure 7. Photographs of 4th and 5th grade girls completing a hands-on experience with plastic panel dams during the GirlTREC summer program (July 9, 2019).

Figure 8. Photograph of the winners of the design competition with Dr. Coffman (July 9, 2019).

Figure 9. Photographs of 1st through 4th grade students completing a hands-on experience with the plastic panel dams during the Butterfield Elementary School Science Club (September 9, 2019).

Figure 10. Photographs of 1st through 4th grade students completing a hands-on experience during the Butterfield Elementary School Science Club (September 9, 2019). Students shown holding drawings of clay core dams.

Figure 11.Photographs of 5th grade students at the Village of Promise completing a hands-on experience with the plastic panel dam prior to the field trip to Guntersville Dam (September 9, 2019).

4.4. Murray Lock and Dam Visit

As described in Section 3.4, students from Little Rock Central High School STEM club were provided with the opportunity to tour the Murray Lock and Dam. Photographs from the site visit are included in this section. As previously mentioned, a second tour of the Murray Lock and Dam with the Little Rock Central High School AVID program was attempted but was not able to be arranged due to scheduling constraints.

(a) (b)

Figure 12. Photographs of the 9th through 12th grade students touring the Murray Lock and Dam with the Little Rock District of the United States Army Corps of Engineers on April 2, 2019.

4.5. Guntersville Lock and Dam Visit

As described in Section 3.5, students from the Village of Promise were provided with the opportunity to tour the Guntersville Lock and Dam. Photographs from the site visit are included in this section. Photographs from the lock portion of the tour with the Nashville District of the United States Army Corps of Engineers are included in Figure 13 through 15 while photogrpahs from the dam portion of the tour with the Tennessee Valley Authority are included in Figure 16.

Figure 13. Photographs of the 9^{th} through 12^{th} grade students touring the Murray Lock and Dam with the Little Rock District of the United States Army Corps of Engineers on April 2, 2019.

(a) (b)

Figure 14. Photographs of the Guntersville Lock tour with the United States Army Corps of Engineers on September 25, 2019. a) Students at the rail as the downstream gate opens (mentor Julia Loshelder shown in the back left) and b) students asking questions of Guntersville Lock Master Ryan Johnson.

Figure 15. Village of Promise students enjoying lunch on the North shore of the Tennessee river at the picnic shelter at Guntersville Lock. Mentor Julia Loshelder also shown (top right).

(a) (b)

Figure 16. Photographs of the Guntersville Dam tour with the Tennessee Valley Authority on September 25, 2019. a) Students being briefed by Chip Troy about the Guntersville

hydroelectric dam, and b) students on the dam looking at the crane that moves gates from slots in the dam.

5. IMPACTS/BENEFITS OF IMPLEMENTATION

Dr Coffman, the principal investigator for this education and outreach project, drew upon his previous record of mentoring and advising underrepresented students to broaden participation of underrepresented groups in STEM disciplines. Proven programs from several institutions were blended to inspire the next generation of researchers and educators. Relationships were fostered and partnerships with organizations such as PSC, LRCHS, and the VP were established.

6. RECOMMENDATIONS AND CONCLUSIONS

Based on the education and outreach that was performed for this project, the following conclusions have been reached and the following recommendations have been developed. This “Exposure to STEM: Diversity in Maritime Transportation” project proved successful in exposing underrepresented students to STEM related concepts by using examples of maritime and multimodal transport infrastructure. First through fourth grade students, in the Engineering Club at Butterfield Elementary School, were afforded with hands-on experiences with soils that fluoresce and panel dams to help make science fun. Ninth through twelfth grade students, in the STEM Club at Little Rock Central High School, were provided with an opportunity to tour the Murray Lock and Dam in Little Rock, Arkansas. Fifth grade students, at the Village of Promise in Huntsville, Alabama, were provided with an opportunity to tour the Guntersville Lock and Dam in Guntersville, Alabama. Undergraduate and graduate students at the University of Arkansas were provided with mentorship exposure while assisting with the hands-on demonstrations and field trips. All of the aforementioned students were made aware that each lock and dam structure is meant to retain water for the purposes of flood control, recreation, electric generation, drinking water and irrigation water access, and maritime transport.

Important collaborations and connections were made through this program. Connections with points of contact within Little Rock Central High School, Philander Smith College, the United States Army Corps of Engineers, and the Tennessee Valley Authority provided a way for students to be educated about maritime and multimodal transport. These connections should continue to be fostered to educate more students about the need for maritime and multimodal infrastructure and to make student aware about the opportunity for careers within STEM fields. More education and outreach projects like this “Exposure to STEM: Diversity in Maritime Transportation” are recommended, to continue to nurture these connections and collaborations.

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