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K-12 OUTREACH

2021

University of Alabama at Birmingham
K-12 Activities:
STEM Events and AUTO STRIDE

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16. Abstract To strengthen and expand UAB's efforts to promote transportation engineering and STEM careers through K-12 educational programs we are proposing the following activities 1. Auto-STRIDE curriculum development and implementation – A yearlong STEM activity for 20 students in the 7th through 10th grade, which will emphasize engineering in autonomous transportation systems (i.e. autonomous vehicles). 2. Girls in Science and Engineering Day - This event will target local middle school aged girls (6th to 8th grade) from the Birmingham area and will invite them to the UAB campus on a Saturday (8:30 am to 3:30 pm). The students will rotate through different fun science and engineering workshops led by UAB professors, scientists, or graduate students. The workshops would be scientifically-based, yet fun, engaging, and active for the girls. 3. UAB Kids in Engineering Day - The event targets 4th and 6th graders from schools across North-Central Alabama and will feature fun and educational activities involving different types of engineering and STEM activities.					
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ABSTRACT

The University of Alabama at Birmingham (UAB) in collaboration with the UAB institute of Transportation Engineers (UAB ITE) student chapter, the Society of Women Engineers (SWE) and a host of student volunteers organized several workforce development events in 2019-2020. These activities were designed to promote Science, Technology, Engineering, and Mathematics (STEM), with particular focus on transportation engineering concepts to K-12 students in the State of Alabama. This final report summarizes three UAB K-12 workforce development initiatives sponsored by STRIDE: a.) the UAB Girls in Science and Engineering Day, an all-female event promoting STEM careers with hands on workshops; b.) the UAB Kids in Engineering Day, a family engineering event targeting 4th through 6th graders and; c.) AUTO STRIDE, a yearlong hands-on workshop series that was intended to explore autonomous transportation system development.

UAB Engineering Days provide a variety of experiential learning opportunities that engaged K-12 students in planning, design, and problem solving, promoted student creativity / teamwork, all provided in an engaging urban campus environment. The 2019/2020 events were well attended, successful, and received positive feedback from participants.

Unfortunately, in March of 2020 the COVID-19 global pandemic coupled with ongoing UAB campus policies (for the protection of community health and safety) halted the year-long AUTO STRIDE workshop series (already in progress). The enduring nature of the COVID-19 pandemic prevented the return of K-12 activities to the UAB campus throughout the grant period of performance. Program participants were informed of an initial delay and ultimately the termination of the AUTO STRIDE workshop series. As a result, the intended summary analysis and publication of workshop outcomes will not be available until the hands-on program can be fully executed. Research faculty have completed the development of this outreach curriculum and will reengage the present / future cohort of on-campus students in the field of autonomous transportation system development.

The activities undertaken in this STRIDE effort can serve as an example that other Universities can replicate to empower young students into becoming engineers and pursuing transportation engineering as a potential career choice.

Keywords: K-12 education outreach, workforce development, STEM, transportation, autonomous transportation

EXECUTIVE SUMMARY

A consensus of available literature has well established that high quality / hands-on workshops and programs offered at the K-12 level can effectively promote an early interest in science, technology, engineering, and mathematics (STEM) [Barakos, Lujan, & Strang, 2012; Cunningham, 2009]. These experiences establish not only an initial interest in STEM fields but are positively correlated with future employment in the respective professions [Katehi et al., 2013]. Leaders in education, politics, and industry alike understand the urgency for improving STEM competency to meet the socioeconomic challenges of our world [English, L.D, 2016; Caprile et al., [2015](#); Honey et al., [2014](#); Prinsley and Baranyai, [2015](#)]. Among the emerging needs is the development of a diverse workforce capable of designing the next generation of transportation infrastructure. Taking the necessary steps to promote transportation-engineering careers at an early age should be a priority for the US DOT, state DOTs, and the ITE.

To that end, The University of Alabama at Birmingham (UAB) in collaboration with the UAB institute of Transportation Engineers (UAB ITE) student chapter, the Society of Women Engineers (SWE) and a host of student volunteers organized several workforce development events in 2019/2020. These activities were designed to promote Science, Technology, Engineering, and Mathematics (STEM, with particular focus on transportation engineering) concepts to K-12 students in the State of Alabama.

The first initiative was the UAB Girls in Science and Engineering Day, an all-female student event promoting STEM careers with hands-on workshops focused on engineering and science. The event promotes equality and combats gender bias in those professions often associated with low female workplace representation. Among the positive results of our exit survey, all attendees indicated that they enjoyed the event but more importantly, 100% felt they were just as capable to pursue science and engineering as their male counterparts.

The second initiative was the UAB Kids in Engineering Day, a Family Engineering event targeting 4th, 5th, and 6th graders in the Birmingham, Alabama area. The event utilized the theme of “Escape from Engineering Island”, to encourage active participation via hands-on experiences across the disciplines of Biomedical, Civil, Electrical, Materials, and Mechanical Engineering.

The final effort was the UAB AUTO STRIDE workshop; devised as a yearlong STEM activity to emphasize emerging engineering technologies in autonomous transportation systems. Seventeen area youths (7th – 10th Grades) were selected to participate based on diversity, availability, prior participation at UAB summer camps (reliability), and their interests in continued STEM educational opportunities. Teams were created to devise, design, program, and build vehicles capable of autonomously traversing a scale urban obstacle course via smart sensors and on-board image processing. Unfortunately, in March of 2020 the COVID-19 global pandemic coupled with ongoing UAB campus policies (for the protection of community health and safety) halted the year-long AUTO STRIDE workshop series (already in progress). The enduring nature of the COVID-19 pandemic prevented the return of K-12 activities to the UAB

campus throughout the grant period of performance. Program participants were informed of an initial delay and ultimately the termination of the AUTO STRIDE workshop series. As a result, the intended summary analysis and publication of workshop outcomes will not be available until the hands-on program can be fully executed. Research faculty have completed the development of this outreach curriculum and will reengage the present / a future cohort of on-campus students in the field of autonomous transportation system development.

The aforementioned UAB initiatives provided a wide variety of K-12 experiential learning opportunities that engaged students in planning, design, and problem solving, promoted student creativity and teamwork, and in our opinion delivered positive educational experiences. Nearly 1800 K-12 student contact hours were provided via this STRIDE sponsored effort.

The activities undertaken in this project can serve as an example for other Universities interested in empowering young students in becoming engineers and pursuing transportation engineering as their career choice.

1.0 INTRODUCTION

Background

Serving the future needs of our nation's transportation infrastructure requires the development of a skilled and adaptable workforce capable of using tools and technology not yet realized. Advances in autonomous and electric vehicles, for example, may soon reshape the very fundamentals of urban and intra/interstate travel (Fagnant et al., 2015, Huang, 2021). Changes in physical infrastructure, funding mechanisms, and public safety would follow from their adoption.

Recognizing these needs and under the sponsorship of STRIDE, UAB has undertaken several initiatives to introduce transportation engineering and STEM principles to K-12 students in Alabama. Increasing student awareness of engineering and the work of transportation engineers while engaging them in participatory, experiential learning activities is the primary aspiration. As students become familiar with emerging technologies and their underlying engineering principles, the connection between science and everyday life is solidified. Young people making these associations are more likely to consider engineering as a career path and pursue future training in related fields.

Objectives and Scope

Scientific discovery and technological breakthroughs are the primary engines not only for expanding the frontiers of human knowledge but also for responding in innovative, practical ways to the challenges and opportunities of the 21st century. As a result, high-quality science, technology, engineering, and mathematics (STEM) education is critical for the prosperity and security of our Nation. National studies and international comparisons have repeatedly shown that STEM education in the United States needs to be improved. To strengthen and expand UAB's efforts to promote transportation engineering and STEM careers through K-12 educational programs we conducted the following activities:

1. Girls in Science and Engineering Day,
2. Kids in Engineering Day,
3. AUTO STRIDE Workshop Series.

2.0 EDUCATIONAL PROGRAMS

Girls in Science and Engineering Day

2.1 Girls in Science and Engineering Day Narrative

Girls in Science and Engineering Day (GSED) was created in 2011 as a unique event designed to inspire and empower Birmingham, Alabama area middle school girls to excel in science and engineering fields.

The STRIDE sponsored UAB Girls in Science and Engineering Day was held on October 26th 2019 on the urban campus of the University of Alabama at Birmingham. This all day event (8:30 AM -3:30 PM), hosted 80 middle school aged girls (6th to 8th grades) from the greater metropolitan region. Registration was open to all, resulting in a wide cross section of represented demographics. Participants engaged in scientifically based workshops provided by faculty, scientists, and graduate students across the UAB campus. Topics in 2019 included: engineering, chemistry, animal behavior / reptilian biology, computer science, forensics, virtual reality, 3D printing, and medical technology (MRI).

Kathryn Lanier, Ph.D., STEM Education Outreach Director for Southern Research gave the keynote lecture breaking down STEM stereotypes and motivating the young women to pursue their dreams.

Over 560 K-12 student contact hours were generated as part of this STRIDE activity.

2.1.2 Girls in Science and Engineering Day

Collaborators and volunteers to staff the 2019 GSED originated from the UAB institute of Transportation Engineers (UAB ITE) student chapter, the Society of Women Engineers (SWE) and a host of general student volunteers (Figure 1).



Figure 1: Fall 2019 GSED Volunteers

As noted in the UAB School of Engineering News (Appendix Item 5):

"I am proud of our student volunteers," said GSED organizer and civil engineering professor Virginia Sisiopiku. "Their warm welcome, along with their personal commitment to STEM, had a profound impact on our young guests. I am confident events like this help create a positive perception regarding women in engineering and science."

2.1.3 Girls in Science and Engineering Day Impacts

The true impact of these K-12 activities will not be fully realized for years to come. In the interim, Figures 2 and 3 are representative of our intended outcome: happy and engaged young women developing a passion for STEM education.



Figure 2: Fall 2019 GSED Circuits Demonstration / Solder Station



Figure 3: Fall 2019 GSED Keynote Speaker (Dr. Kathryn Lanier)

Post event impact data were collected via Google Forms, an online survey tool. Of the 80 participants, 45 (56%) volunteered to participate. Overall responses were positive / complementary. A high percentage of students indicated enjoyment, interest in scientific careers, and a desire to pursue a college education in STEM. Full results are available in Appendix Item 3.

2.1.4 Girls in Science and Engineering Day Recommendations

Girls in Science and Engineering Day was created in 2011 as a unique event designed to inspire and empower middle school girls to excel in science and engineering fields. Each subsequent year saw a growth in interest, participation, and community recognition. Unfortunately, in 2020 COVID-19 prohibited the delivery of K-12 activities on the UAB campus until such time as community health improves. Students and parents alike are presently starved for hands-on experiences. Resources to expand these meaningful interactions will be essential to reengage STEM interested students negatively impacted by hybrid and remote K-12 learning during the global pandemic.

Kids in Engineering Day

2.2 Kids in Engineering Day Narrative

In celebration of the National Society of Professional Engineers Week, UAB hosted its eighth annual Kids in Engineering Day (KIED). The event was held on the urban campus of the University of Alabama at Birmingham February 15th and again on 22nd of 2020 (8:00 AM till 3:00 PM) to maximize community participation and attendance. The event targeted 4th and 6th graders from schools across North-Central Alabama and utilized the 2020 theme of “Escape from Engineering Island”, to encourage active participation via hands-on experiences across the disciplines of Biomedical, Civil, Electrical, Materials, and Mechanical Engineering.

Specific engineering activities included:

Biomedical: the theory of freezing point depression and how salt alters water.

Civil: what shapes can make a weak material stronger.

Electrical: how to solder components onto a circuit board, how to communicate in Morse code.

Materials: what does it mean for something to be waterproof.

Mechanical: how to build something that will float / a boat hull.

Registration was open to all, resulting in a wide cross section of represented demographics. Parents of attendees were invited to attend a parallel tack (Parent Educator Program) to answer questions about the STEM fields and Engineering.

The 2020 KIED event saw 89 community participants across the two days, representing over 620 K-12 student contact hours.

As noted in the UAB School of Engineering News (Appendix Item 6):

“We want all kids to understand that there are practical applications that come from the math and science they learn in school. We also want to create an environment for kids to be hands-on and have the chance to try new things. We want all kids to have confidence in their ability in STEM fields, but it’s especially important for girls and other groups who are traditionally underrepresented in science and engineering.”

2.2.2 Kids in Engineering Day Collaborations

Collaborators and volunteers to staff the 2020 KIED originated from the UAB faculty, UAB Institute of Transportation Engineers (UAB ITE) student chapter, the Society of Women Engineers (SWE) and a host of general student volunteers. 53 volunteers, representing over 700 hours, were needed to plan, organize, and staff the event.

2.2.3 Kids in Engineering Day Impacts

The true impact of these K-12 activities will not be fully realized for years to come. In the interim, Figures 4, 5, and 6 are representative of our intended outcome: happy and engaged area youth developing a passion for STEM education.



Figure 4: Spring 2020 KIED Event: Civil Engineering ~ Stronger Shapes



Figure 5: Spring 2020 KIED Event: Mechanical ~ Survival Rafts



Figure 6: Spring 2020 KIED Event: Workshop Participants

Due to the nature of this event and the age of primary participants, no formal evaluation was carried out. Exit discussions with parents / kids were positive and as best described in Appendix Item 10:

“Emma Schmidt, SWE at UAB President, notes that year after year some of the same kids return to participate in this event, “and have a sense of confidence about themselves that we don't even see in our college volunteers,” she says. For example, soldering is a skill that intimidates many undergraduate engineering students, Schmidt says, and this event, “has 5th graders soldering whole circuits and motors onto their cars.”

This event is about fostering early ideas and confidence in Alabama’s youth. Their attendance and active participation is the true deliverable. A draft evaluation form was developed for past events and proved cumbersome for data collection from such a young audience.

2.2.4 Kids in Engineering Day Recommendations

Kids in Engineering Day was created as a unique event designed to inspire and empower younger students (4th and 6th grade) from schools across North-Central Alabama to excel in science and engineering fields. Each year a growth in interest, participation and community recognition has been recorded. Unfortunately, in 2020 COVID-19 prohibited the delivery of K-12 activities on the UAB campus until such time as community health improves. Students and parents alike are presently starved for hands-on experiences. Resources to expand these meaningful interactions will be essential to reengage STEM interested students negatively impacted by hybrid and remote K-12 learning during the global pandemic.

UAB AUTO STRIDE

2.3.1 UAB AUTO STRIDE NARRATIVE

UAB AUTO STRIDE was devised as a yearlong STEM activity to emphasize emerging engineering technologies in autonomous transportation systems.

Lead by Dr. Abi Yildirim, student teams were created to devise, design, program, and build model vehicles capable of autonomously traversing a scale urban obstacle course. Seventeen area youths (7th – 10th grades) were selected to participate based on diversity, availability, prior participation (reliability), and their interests in continued STEM educational opportunities (see Figure 7).



Figure 7: 2020 UAB AUTO STRIDE Participants

Student teams attended monthly workshops (October 2019 – March 2020) to first learn about current and emerging technologies that are shaping the future of transportation such as Artificial Intelligence (AI), Deep Learning, smart sensors, image processing and alternative / electrical power drive systems. Following instruction, student teams adapted the acquired knowledge into modifications of a TRAXX TRX4 Sport Remote Control truck that would ultimately be utilized to autonomously traverse the obstacle course (see Figure 8). All remote control capabilities of the parent vehicle were disabled. Additional skills acquired by the student teams in 3-D printing were utilized to configure custom equipment mountings for the competition vehicles (See Figure 9). Modifications were unique to individual student teams.

Monthly workshop themes included:

- Programming Arduino and Syntaxes. Programming Pulse Width Modulation (PWM)
- Programming Python, Introduction the Raspberry Pi (RBPi)
- Programming ultrasound sensor, distance measurement and obstacle avoidance
- Programming servos for directional steering
- Programming serial communication between Arduino and RBPi
- Interfacing ultrasound sensor with RBPi
- Introduction to CAD with Ultimaker 3D Printer and Cura software
 - Above presentations available (Appendix Items 12-19)



Figure 8: Autonomous Vehicle Testing and Design

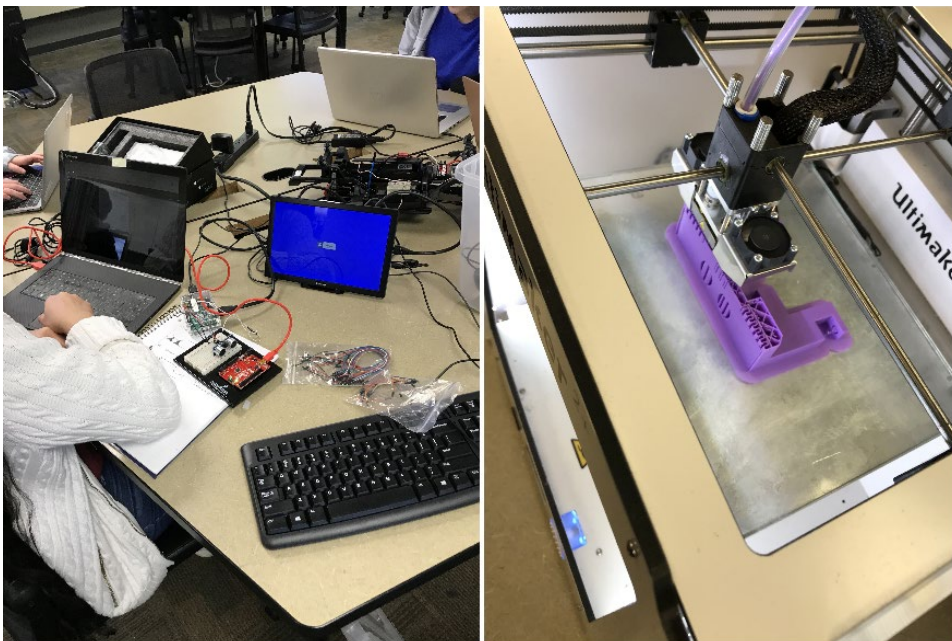


Figure 9: Custom 3-D Printing for Autonomous Vehicle Designs

Regrettably, the AUTO STRIDE workshop series was compromised by the onset of the COVID-19 pandemic. K-12 participants were administratively prevented from returning to UAB campus throughout the grant period of performance. Given the collaborative team nature, hands-on assembly requirements, and specialized equipment needs to complete deliverables, an on-line alternative delivery method was not practical for the remaining tasks. Research faculty have completed the development of this outreach curriculum and will reengage the present / a future cohort of on-campus students in the field of autonomous transportation system development.

Despite these unforeseen and persistent limitations, the 2020 AUTO STRIDE event generated over 600 K-12 contact hours for workshop participants focused solely on transportation engineering.

2.3.2 UAB AUTO STRIDE Collaborations

No outside collaborators were utilized during the UAB Auto- Stride event. One undergraduate volunteer (Carlos Gallegos) and one graduate student volunteer (Sahaj Patel) were selected by Dr. Abi Yildirim to assist in the delivery of Auto Stride student workshops October 2019 – March 2020.

2.3.3 UAB AUTO STRIDE Impacts

As stated previously, the Global COVID pandemic prevented the completion of the AUTO STRIDE workshop series within the grant period of performance. As a result, the intended summary analysis and publication of workshop outcomes will not be available until the hands-on program can be fully executed. 2019-2020 program students were engaged / productive and would have produced quality deliverables if given full opportunity. The UAB faculty are confident that this activity will be a successful outreach program for years to come. Appendix Item 11 is an example parent letter, reinforcing the impact these activities have on young lives and how they can cultivate future interest.

2.3.4 UAB AUTO STRIDE Recommendations

2019-2020 was the pilot launch of UAB AUTO STRIDE. As in all educational materials, there will be slight modifications and edits to future deliveries. The faculty feel that it is promising hands-on workshop. Future offering will be streamlined for shorter delivery alternatives (summer camps for instance).

3.0 EDUCATIONAL PRODUCT

No elements of this type were proposed in the current STRIDE effort.

4.0 CONCLUSION

The aforementioned UAB initiatives provided a wide variety of K-12 experiential learning opportunities that actively engaged students and in our opinion delivered positive educational experiences. Nearly 1800 K-12 student contact hours were generated via this STRIDE sponsored effort.

Obviously, the research faculty were disappointed that AUTO STRIDE could not be conducted as intended due to the ongoing COVID pandemic. This workshop series, in particular, was designed to provide a depth of knowledge and student/faculty interactions not possible in traditional day or summer camps. This STEM activity, emphasizing emerging engineering technologies in autonomous transportation systems, will be redeployed in the future.

UAB student participants gained exposure to a variety of engineering concepts throughout the three activities conducted (Girls in Engineering Day, Kids in Engineering Day, and the AUTO STRIDE workshop series). It is the research faculty's firm belief that these interactions are crucial to the development of future engineering practitioners. We will continue to inspire young minds and reinforce the value of transportation-related careers with the support of the STRIDE research center.

5.0 ATTACHMENTS

1. GSED Fall 2019 Flyer
2. GSED Fall 2019 Speaker
3. GSED Fall 2019 Surveys
4. GSED Fall 2019 Certificates
5. GSED Fall 2019 Newsbrief
6. KIED Spr 2020 Announcement
7. KIED Spr 2020 Parent Email
8. KIED Spr 2020 Registration Flyer
9. KIED Spr 2020 Presentation
10. KIED Spr 2020 Newsbrief
11. AS Parent Letter
12. AS Lecture 00
13. AS Lecture 01
14. AS Lecture 02
15. AS Lecture 03
16. AS Lecture 04

- 17. AS Lecture 05
- 18. AS Lecture 06
- 19. AS Lecture 07

6.0 REFERENCE LIST

1. Barakos, L., Lujan, V., & Strang, C. (2012). Science, technology, engineering, mathematics (STEM): Catalyzing change amid the confusion. Portsmouth, NH: RMC Research Corporation, Center on Instruction.
2. Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM: Current perceptions. *Technology and Engineering Teacher*, 70(6), 5–9.
3. Caprile, M., Palmen, R., Sanz, & Dente, G. (2015). *Encouraging STEM studies for the labour market* (Directorate-General for Internal Policies: European Parliament).
4. Cunningham C. (2009), “Engineering is Elementary”. The Bridge, National Academy of Engineering.
5. English, L.D. STEM education K-12: perspectives on integration. *IJ STEM Ed* **3**, 3 (2016).
6. Fagnant, Daniel J. and Kara Kockelman, (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Transportation Research Part A: Policy and Practice*, 77, 167-181.
7. Honey, M., Pearson, G., & Schweingruber, A. (2014). *STEM integration in K-12 education: status, prospects, and an agenda for research*. Washington: National Academies Press.
8. Huang, Kai. 2021 "INNOVATIONS IMPACTING THE FUTURE OF TRANSPORTATION: AN OVERVIEW OF CONNECTED, AUTOMATED, SHARED, AND ELECTRIC TECHNOLOGIES " University of Texas.
9. Katehi L., Pearson, G., and Feder, M. (2013), “The Status and Nature of K–12 Engineering Education in the United States”. The Bridge, National Academy of Engineering.
10. Prinsley, R., & Baranyai, K. (2015). *STEM skills in the workforce: what do employers want?* Occasional Papers Series, issue 9, March. Office of the Chief Scientist.