

## **IEEE CSS Outreach Fund**

1. Project title. STEM beyond the borders: An Engineering Enrichment Outreach Program-Part II
2. Project lead and contact information, including IEEE membership number. Victoria Serrano. IEEE membership number: xxxxxxxx. Technological University of Panama, Phone: +507-xxxx-xxxx. Address: Victoria Serrano xxx, xxx xxx, David, Chiriqui. Email: [victoria.serrano@utp.ac.pa](mailto:victoria.serrano@utp.ac.pa).
3. Other key people with affiliations and e-mail addresses.

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4. Funding requested and budget. The total requested is \$15,000.00 which includes materials and equipment for twenty participants of the program, a contingency value and institutional overhead. Materials and equipment locally purchased (\$6,020.02): laptops (\$3,927.20), hot glue sticks (\$20), hot glue gun (\$40), solder wire (\$15.82), soldering and hot air gun station (\$300), AA alkaline batteries (\$132), wire strippers (\$80), screwdriver sets (\$80), decorating items (\$20), poster paper (\$50), pencils, erasers, notebooks (\$80), assorted markers (\$20), t-shirts (\$800), snacks (\$360), banner (\$50), certificate awards (\$45). Furthermore, some materials and equipment are required to be purchased online since they are not available locally (\$6,966.99). They include: mobile platform for Arduino boards (\$1,066.39), Arduino Mega boards (\$1,237.75), Adafruit motorshields (\$557.35), shield stacking headers for Arduino (\$42.90), ultrasonic sensors (\$73.94), bases for ultrasonic sensor (\$47.67), servo motors (\$197.78), 3D Printer (\$3,518.07), plastic filament for 3D printer (\$225.14). A contingency value of 5% of the total of material and equipment was included in case prices rise at the time of purchase (\$649.35). Additionally, professors and researchers are not allowed to manage funds on their own for transparency purposes; therefore, an institutional overhead of 10% of the total of material, equipment and contingency is calculated, so that Fundacion Tecnologica de Panama can manage the money (\$1,363.64). Additional details about the budget are provided in the spreadsheet attached.

We are also applying for funding at the Secretaria National de Ciencia, Tecnologia e Innovacion (SENACYT) in Panama, but this funding has not been secured yet. Additional funding will be requested to the Graduate and Professional Student Association (GPSA) at ASU.

5. Project motivation, objectives, and deliverables.

### **Project motivation:**

As seen across Latin America, it has been very difficult to excite students about and steer them towards engineering careers. In an effort to meet specific STEM needs of Panamanian high school students, we propose an outreach program entitled: STEM Beyond Borders. This program will impact twenty (20) 11th grade high school students (more than 50% females) over a period of six weeks during the spring of 2017. The participating schools are from the David school district in the province of Chiriqui: Felix Olivares Contreras High School, San Agustin High School, San Francisco de Asis High School, Beatriz Miranda de Cabal High School and Bilingual Adventist High School. Commitment letters from participating schools have been already secured (see attachments).

Designed to capture the imaginations of students via hands-on engineering projects and get students excited about pursuing careers in engineering, the program leverages years of time-tested student-centered mentor-driven activities that have been successfully applied to more challenging groups (e.g. over 200 4th, 5th and 6th grade underrepresented minority students from impoverished - Title I, free-lunch - backgrounds). The program will be implemented by a team with considerable outreach experience (see below). The team leaders consist of two professors from the Technological University of Panama, one engineering PhD student and 2 electrical engineering professors from Arizona State University (ASU).

### **Objectives:**

1. To demonstrate the utility of new empowering engineering outreach materials and techniques for high school students everywhere-particularly in Latin America.
2. To demonstrate a program that can be sustained and scaled up across Panama and Latin America.

3. To empower program participants with skills and tools that enable them to immediately participate in the ongoing robotics revolution. They include: controller design, programming, 3D design and path planning.
4. To demonstrate the importance of school work, academic success, using projects/internships to discover one's technical passions and participating in professional organizations such as IEEE to promote continued professional development.

#### **Deliverables:**

- Project report due: December 2016 for the preparation of materials with volunteers from the University and April 2017 with the results of the outreach program and evaluation.
  - Abstract submission deadlines: August 2017 for the conference in Hawaii (<http://hiceducation.org/>) and April 2017 for the Latin American conference (<http://lacei.org/index.php/events/upcoming-events/conference2016>)
  - Conference participation: 16th Hawaii International Conference on Education in January 2018 and/or 15th Latin American and Caribbean Consortium of Engineering Institutions (LACCEI) International Conference on Engineering and Technologies in July 2018. Participation at the conference will allow the dissemination of the results obtained from the outreach program, highlighting its importance in the K-12 education.
6. Project duration, tasks, and schedule.

#### **Material Preparation**

- **August 1st-31st:** Build and test initial experiments for the project “STEM Beyond the Borders-Part II” with the participation of engineering students at the Technological University of Panama and the Micro-Air Vehicles (MAV) club members at ASU.
- **September 1st-30th:** Preparation of Instruction Manuals.
- **October 1st-31st:** Purchase of materials locally and through the internet.
- **November 1st – 30th:** A report will be prepared and submitted to the Control Systems Society Outreach Funds before the start of the outreach program.

#### **Program Schedule**

- **March 3rd, 2017:** Session 1 of the STEM Beyond the Borders program. Students will assemble the structure of their robotic cars. A survey will be conducted at the beginning of the program to measure student’s perception toward science, technology, engineering and mathematics.
- **March 10th, 2017:** Session 2 of the STEM Beyond the Borders program. Students will learn how to program the Arduino boards starting from a simple example to light on an LED. Then, they will be able to develop a program to control the motors of their robotic cars with the help of the Adafruit Motorshields.
- **March 17th, 2017:** Session 3 of the STEM Beyond the Borders program. Students will learn how to read distance with an ultrasonic sensor and they will use that information to control the servo motor and the motor-wheels. A survey will be conducted on the third week of the program to evaluate the progress to date. A videoconference will take place with the participation of PhD Student in Mechanical Engineering, Michael Thompson, to highlight the importance of going to college and how outreach programs can benefit them to shape their career interests.
- **March 24th, 2017:** Session 4 of the STEM Beyond the Borders program. Students will have a 3D modelling session to learn how to design 3 dimensional structures. They will design and 3D print parts to be integrated with their robotic cars.
- **March 31st, 2017:** Session 5 of the STEM Beyond the Borders program. Students will prepare a poster and set up their robotic cars to prepare for the competition.
- **April 7th, 2017:** Session 6 of the STEM Beyond the Borders program. Students will present their posters and participate in a obstacle avoidance competition. A survey will be conducted at the end of the program to evaluate how the program help shape student’s interests toward science, technology, mathematics and engineering, with a special emphasis in how control systems improve the dynamics of their robotic cars.

#### **Evaluation**

- **April 7th:** Part of the materials will be donated to participating schools as part of the sustainability plan. The rest of the equipment will remain at the Technological University of Panama for the

development of future outreach programs. An evaluation of the program will be conducted with professors, volunteers and participating schools.

- **April 8th-31st:** A final report will be prepared and submitted to Control Systems Society Outreach Fund.

7. Qualifications of personnel.

- Victoria Serrano

The PI is uniquely qualified to pursue this project because of her significant experience in the area control systems and robotic devices and her recent work on Lego Mindstorms kits and Arduino Robotic Cars for educational purposes. Victoria Serrano is a PhD candidate in Electrical Engineering at Arizona State University (ASU). She received a Bachelor degree in Electrical and Electronic Engineering from the Technological University of Panama, Panama in 2006 and a Master of Engineering degree in Power Systems from the same university in 2009. Victoria also obtained a Master of Science in Engineering degree in Control Systems from ASU in 2012. Victoria received a Fulbright fellowship to pursue her master's degree at ASU. She was also awarded a Panamanian government fellowship to continue her PhD program. From 2007 to 2009, she worked as an assistant professor at the Technological University of Panama and is currently on leave to complete her PhD program in July 2016. Her main research focus is on the system identification, adaptation and controller design of electrical systems and robots. She was the Vice-President of the Fulbright International Association at ASU from 2011-2013 and is the current Outreach Director and Vice-President of the Micro Air Vehicle (MAV) Club at ASU. Victoria has collaborated with the Science, Technology, Engineering, Arts and Mathematics (STEAM) enrichment program to motivate young students to pursue engineering careers that have impacted over 200 K-12 students during the past 3 years. She has been involved with the STEAM program for the last two years and recently developed her own curriculum with the Arduino Robocars. Last year, Victoria was awarded a grant from EPICS in IEEE to develop the outreach program "STEM Beyond the Borders-Part I" in October, 2015 in Panama. This program involved the participation of fifteen 12th graders from three participating schools and the use of Lego Mindstorms EV3. As a result of the outreach programs in Arizona and Panama, Victoria presented the results at the 14th Annual Hawaii International Conference on Education. The citation is as follows:

1. V. Serrano, M. Thompson and J. Aldaco, K. Tsakalis, A. Rodriguez, "Building a Lego EV3 Snake to Improve the STEM Education of 12th Graders in Panama," Proceedings of 14th Annual Hawaii International Conference on Education, Honolulu, HI, January 3rd – 7th, 2016. See <http://www.hiceducation.org/>.
2. M. Thompson, V. Serrano, D. Ixtabalan, V. Garcia, A. Godinez, A. Rodriguez, K. Tsakalis, "Building a Mechanical Flapping Bird and Arduino Robotic Cars for Educating Youths in 7th, 8th and 9th Graders at Arizona State University," Proceedings of 14th Annual Hawaii International Conference on Education, Honolulu, HI, January 3rd – 7th, 2016. See <http://www.hiceducation.org/>.

The two papers discussed the benefit of hands-on projects for motivating middle and high school students to pursue engineering. These papers highlight the impact on minority high school students by using a hands-on approach to learning mathematical concepts.

- Michael Thompson

Michael Thompson earned a B.S.E. degree in the field of Mechanical Engineering from Arizona State University in the Ira A. Fulton School of Engineering in 2012. He will receive his PhD in mechanical engineering in the field of Modeling, Analysis, Control, Design, and Rapid Prototype of Micro Air Vehicles by December 2017. Michael has mentored middle and high school (7<sup>th</sup> - 12<sup>th</sup> grade) students participating in his six week student-centered mentor-driven engineering outreach program during the past four years. Participating students designed, built, tested and analyzed two-mechanical flapping wing birdlike vehicles. Moreover, they worked alongside a team of experienced engineers - graduates of Arizona State University (ASU) that are committed to mentoring at risk students. Student participants were exposed to ASU student organizations such as the Micro Air Vehicle (MAV) Club and the Society of Hispanic Professional Engineers (SHPE) as well as highly motivated engineering alumni. Michael's NASA Space Grant sponsored outreach programs have captured the imaginations of participants through a hands-on approach - incorporating fundamental ideas from flight, physics and general engineering. The

program story was highlighted in the ASU News and featured the program activities in a recent (widely disseminated) article:

<https://asunow.asu.edu/20160315-inspiration-springs-engineering-education-outreach-effort>. Michael's programs have helped over 311 minority (female and male) at-risk students - students who lack mentors, role models and are generally not exposed to such programs. Of the 311, 216 participated during Fall 2012-Spring 2014, 60 during Fall 2014-Spring 2015, and 35 during Fall 2015-Spring 2016. Direct consequences of Michael's programs and mentoring are as follows: (1) student participants learn that engineering can be lots of fun, (2) students overwhelmingly see engineering as a possible career path that they are eager to pursue. By the end of Michael's six week engineering enrichment activities, student participants know what type of engineer they want to be! Observing this transformation is truly amazing. For his work, Michael was recently honored with a *2016 ASU Outstanding Mentoring Award* from the ASU Graduate Professional Student Association (GPSA).

- Dr. Konstantinos Tsakalis

Dr. Konstantinos Tsakalis is a Professor and Associate Director of Infrastructure in the Department of Electrical, Computer and Energy Engineering at Arizona State University. He received his PhD in Electrical Engineering from the University of Southern California in 1988. He has over 30 years experience in the field of automatic control systems. Dr. Tsakalis is an expert in the area of adaptive control systems and brings over 30 years experience in the area of intelligent embedded systems. His expertise is in the theory and applications of control systems, adaptive control, system identification and optimization, where he has co-authored the book *Linear Time-Varying Systems: Control and Adaptation*, published by Prentice-Hall. He has published over 200 technical papers. He has worked on the integrated system identification and controller design and the implementation of high-performance multivariable controllers for semiconductor manufacturing applications and has been awarded several US Patents. He has also worked on the application of robust control theory, system identification and optimization principles in various industrial problems in collaboration with Honeywell and EPRI. More recently, his activities include power system and biomedical applications, and in particular, prediction and control of epileptic seizures. His educational objectives are to provide students with an operational understanding and hands-on experience with modern system identification and feedback controller design techniques and implementation of embedded control systems. He is the doctoral advisor of Victoria Serrano.

- Dr. Armando Rodriguez

Dr. Armando A. Rodriguez is a professor of Electrical Engineering at Arizona State University. He received his PhD in Electrical Engineering from the Massachusetts Institute of Technology (MIT) in 1990. He has over 30 years experience in the field of automatic control systems. Dr. Rodriguez is an expert in multivariable control system design and brings over 30 years experience in the area of intelligent embedded systems. He received a 1998 White House Presidential Excellence Award from President Bill Clinton for his research-mentoring-outreach program on FAME (Flexible Autonomous Machines operating in an Uncertain Environment). He also received a Boeing A.D. Welliver 1997 Fellowship for this work. Dr. Rodriguez had led outreach programs for over 25 years. These programs have been funded by the National Science Foundation (NSF) and industry. This work has resulted in over \$6M in scholarship disbursements to needy students studying engineering. He is the author of three (3) texts on control systems and over 200 technical papers. Dr. Rodriguez currently leads an engineering industrial advisory board of over 25 companies. He is the doctoral advisor of Michael Thompson.

- Dr. Iveth Moreno

Dr. Iveth Moreno is a professor of Electrical Engineering at the Technological University of Panama (UTP). She obtained her PhD in Automation and Robotics at the Universidad Politecnica de Madrid, Spain. She is the Coordinator of Research at the UTP-Regional Center in Chiriqui. She obtained a Master in Science with Specialization in Automation and Robotics at the Technological University of Panama, Panama. Her research interests are in the areas of robotics education and mobile robots, artificial intelligence and sensors.