

ISEC 2020

10th IEEE Integrated STEM Education
Conference

Virtual Online Conference
Princeton, New Jersey, USA
Saturday, August 1, 2020

Program Book



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Many thanks to Emily A. Carter, Ph.D., Gerhard R. Andlinger Professor in Energy and the Environment and Dean of SEAS, Princeton University; Andrea Mameniskis, Assistant to the Dean; and Michelle Horgan, Senior Conference and Event Manager, for your kind hospitality in hosting ISEC '20!

We also appreciate very much the contributions of the volunteer reviewers, session chairs, conference staff, and “friends of the conference.” The conference benefits greatly from the gifts of your time, skills, and knowledge. We would like to acknowledge the following IEEE officers for their support of the 2020 IEEE Integrated STEM Education Conference

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CALENDAR of EVENTS – AUGUST 1, 2020

- 9:00am – 9:15am - **Introduction**
- 9:15am – 10:00am - **Keynote Speaker 1 – David S. Touretzky**
“What Every Child (And Teacher) Should Know About Artificial Intelligence”
Dr. David S. Touretzky
Professor of Computer Science
Carnegie Mellon University
- 10:00am – 10:45am - **Keynote Speaker 2 – Naveen Verma**
“Bringing Artificial Intelligence into the Real World”
Dr. Naveen Verma
Professor of Electrical Engineering
Princeton University
- 10:45am – 11:30am - **Keynote Speaker 3 – Burt Dicht**
“Bringing Artificial Intelligence into the Real World”
Mr. Burt Dicht
Director, Student and Academic Education Programs
Institute of Electrical and Electronics Engineers (IEEE)
- 12:00pm – 6 months - **K-12 Poster Presentation – Morning Session**
- 12:00pm – 6 months - **Paper Presentations – Midday Sessions**
Track 1 – Full Papers I
Track 2 – Works-in-Progress I
Track 3 – Full Papers II
Track 4 – Full Papers III
- 12:00pm – 6 months - **Workshops**
- 12:00pm – 6 months - **Paper Presentations – Afternoon Sessions**
Track 5 – Full Papers IV
Track 6 – Works-in-Progress II
Track 7 – Full Papers V
Track 8 – Full Papers VI
Track 9 – Full Papers VII
- 12:00pm – 6 months - **K-12 Poster Presentation – Evening Session**

These video presentation will be online at

Virtual Conference: https://IEEE_ISEC.info

Key Speaker can also be viewed at

http://ieeetv.ieee.org/live_event/IEEE_ISEC

KEYNOTE SPEAKER
DR. DAVID S. TOURETZKY



David S. Touretzky is a Research Professor in the Computer Science Department and Neuroscience Institute at Carnegie Mellon University in Pittsburgh, PA. He received his BA from Rutgers University in 1978 and his PhD from Carnegie Mellon in 1984. Dr. Touretzky is the chair of the AI4K12 Initiative (AI4K12.org), a joint project of the Association for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA) that is developing national guidelines for teaching AI in K-12. He is also the creator of Calypso for Cozmo and Cloud Calypso, an intelligent robot programming framework that puts real artificial intelligence tools into the hands of children.

ABSTRACT

Artificial Intelligence technology is delivering major benefits to society, from friendly intelligent assistants to self-driving cars. But it is also a source of new threats, including loss of privacy due to ubiquitous surveillance, and the potential misuse of deep fakes. Children need to understand this technology so they can separate fact from fiction and begin preparing for careers in an AI-powered world. Since 2018, in a project funded by the National Science Foundation, I have been working with a group of K-12 teachers and computer science experts to develop national guidelines for teaching AI in K-12. We've identified "Five Big Ideas in AI" that serve as the organizing framework for the guidelines, and we're now developing grade band progression charts for each big idea. In this talk I'll describe what K-12 students and teachers should know about AI, and how they can develop competencies to advance from AI consumers to AI creators.

KEYNOTE SPEAKER
DR. NAVEEN VERMA



Naveen Verma is a Professor of Electrical Engineering at Princeton University. He received his B.A.Sc from the University of British Columbia in 2003, and his M.S. (2005) and Ph.D. (2009) from the Massachusetts Institute of Technology, 2009. His research focuses on analog and digital integrated circuits, with an emphasis on developing system platforms for emerging applications, especially where considerable computation and instrumentation is required but energy is severely constrained. Important examples include implantable and wearable biomedical systems and remote sensing and processing network nodes. His talk is titled “Bringing Artificial Intelligence into the Real World.”

ABSTRACT

Machines have reached an inflection point, where they can perform at or beyond the level of humans in specific tasks traditionally associated with cognition (vision, language, strategic gameplay). How did this remarkable capability come to be? And why, when we go to deploy machines in even friendly real-world environments, do they so often fail gloriously? We may have set ourselves out on an exciting journey of discovery about artificial intelligence and, indeed, its parallels with human intelligence. But even as we embark on this journey, which is unlikely to conclude anytime soon, we would like to create evermore powerful and intelligent machines. So, how should we proceed, with such an incomplete understanding. This talk will explore the simple realities of what we know about artificial intelligence, and what clues these give us for both the deeper insights we seek and the for the paths we may pursue to build increasingly capable and useful machines.

KEYNOTE SPEAKER MR. BURT DIGHT



Burt Dicht joined IEEE in 2011 and serves as the Director of Student and Academic Education Programs. He oversees IEEE's engineering education accreditation efforts and is responsible for the development and implementation of programs for pre-university and university educators and students. Prior to joining IEEE, he was the Managing Director of ASME's Knowledge and Community Sector. Burt began his career in the aerospace industry in 1982 and held the position as a lead engineer for Northrop Grumman and Rockwell Space Transportation Systems Division. Specializing in systems and configuration integration, he worked on programs such as the YF-23A Advanced Tactical Fighter, the F-18E/F Super Hornet, and the Space Shuttle. Burt is a member of AIAA, IEEE and is an ASME Fellow. He received his B.S. in

Mechanical Engineering from Temple University and an M.A. in History from California State University, Northridge. Mr. Dicht has authored numerous articles on aerospace history and is a frequent guest speaker on space topics. Mr. Dicht volunteers as an Exhibit Explainer for the Intrepid Museum in NYC, serves as a Capt. and Aerospace Education Officer for Civil Air Patrol and is Vice President for Membership for the National Space Society. His talk is titled **"Leveraging the Power of IEEE's Global Communities . . . To Impact as Many Students as Possible: The IEEE Volunteer Pre-University STEM Portal"**

ABSTRACT

IEEE is known for *"Advancing Technology for Humanity."* As impressive as the technology of today is, it is the result of people. Ensuring there is a pool of talented individuals entering engineering and technology fields is an important part of IEEE's mission. The students of today are the engineering and technology experts of tomorrow who will spur innovation and solve the challenges and continue advancing technology for humanity. As a result, IEEE is invested in inspiring the next generation to pursue STEM fields and it is IEEE volunteers who are helping to spark excitement about engineering through their pre-university STEM education programs.

As impressive as IEEE's efforts are each year, we do not know collectively what is being done across the institution. There is no central place for volunteers to share their effective programs with each other, no central resources that volunteers can draw from when developing local STEM programs, and no data collection system to assess impact.

The answer is the **IEEE Volunteer Pre-University STEM Portal**, now under development by Educational Activities with support from MGA, Technical Activities, and other stakeholders within IEEE. The portal is a centralized resource that that will provide operating units (i.e., student branches, chapters, sections, technical societies, etc.) and volunteers' access to opportunities that will enable them to plan and execute pre-university STEM-based activities. ***The intent of the portal is to leverage the reach and strength of IEEE's global communities to impact as many students as possible.***

MR. BURT DIGHT – ABSTRACT - (Continue)

This portal will feature a searchable library of STEM programs and activities and volunteers will have access to “how-to” resources in order to facilitate the execution of these pre-university STEM programs or create their own. Mr. Dicht's presentation will introduce you to the portal, its features and benefits for volunteers, and how it will move IEEE's pre-university STEM programs to the next level.

AWARDS CEREMONY

H. ROBERT (BOB) SCHROEDER BEST PAPER AWARD

Bob Schroeder, a life-long resident of the Trenton, NJ area, was a founding member of the Princeton / Central Jersey Chapter of the IEEE Education Society, serving as its inaugural chair. He retired as the communications and warning officer for the New Jersey Office of Emergency Management, New Jersey State Police, and led a technology consulting company, AdroIt. The Best Paper Award is given in his memory to honor his devotion to and expertise in technical writing and engineering education as well as his service to the conference.

2020 BEST PAPER AWARD NOMINEES

A three-year retrospective on offering an embedded systems course with a focus on cybersecurity

Ravi Rao (Fairleigh Dickinson University, USA)

The Preternship - An Academic-Industry Partnership Model for Early Experiential Learning Experiences in Computer Science Curricula

Matthew Morrison, John Dimpel, and Emory Smith (University of Notre Dame, USA)

Evaluation of a Snake Jaw Robot to Teach Integrated Biology, Mathematics, and Engineering

Lauren Garofalo; Samantha Sandler; Deeksha Seth (Villanova University, USA)

Electrical Engineering Core Course Laboratory Creation for Non-STEM Majors

Christopher Martino, Dan Opila, Brent West, Louiza Sellami, John Stevens, and Deborah Mechtel (United States Naval Academy, USA)

Middle School Students Learn Binary Counting Using Virtual Reality

Eric Nersesian, Michael J Lee, Margarita Vinnikov, Adam Spryszynski, and Jessica Ross-Nersesian (New Jersey Institute of Technology, USA)

2019 BEST PAPER AWARD WINNER

"Application of Text Data Mining To STEM Curriculum Selection and Development"

Andres Fortino (NYU Autonomous Professional Development, USA); Roy E Lowrance (Autonomous Professional Development, USA); Qitong Zhong (NYU School of Professional Studies, USA); WeiChieh Huang (Self-employed, USA)

2019 BEST POSTER AWARD WINNERS

"Open Software and Hardware Blood Glucose Analysis" - Aditya Vidyadharan

"Data Mining and Sentiment Analysis of Real-Time Twitter Messages for Monitoring and Predicting Events" - Maya Albayrak

"Diving into STEM with Underwater Robotics" - Sophie Zhang

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Wei-hsing Wang	Princeton International School of Mathematics and Science

Saturday, August 1 11:30 - 12:30

Poster Session 1

Utilizing Different Types of Synthetic Fabrics as a Cement Reinforcement for Concrete Tile Roofing

Blessed Isaac C Conde and Daniel Jerlan S Coladilla (La Salle Green Hills, Philippines)

This study aims to alleviate the problem of concrete deterioration by introducing a material to be used as a cement reinforcement to concrete roof tiles that will decrease its water absorption percentage, without decreasing its flexural tensile strength score. Five sample groups consisting of four experimental and one control group of downgraded (modified size) flat concrete roof tiles were used for experimentation. The experimental groups were reinforced with equal amounts (15 grams) of acrylic, nylon, polyester, or rayon fabric shreds, respectively. Both experimental and control groups were uniformly treated with water to cement and cement to sand optimal volume ratio. Using the p-value method on Kruskal-Wallis H-test ($\alpha = 0.01$, $N = 10$, $df = 4$) in both tests, results show that each sample group distribution had no significant difference among the other groups in terms of both test scores. Despite both p-values ($p \approx 0.081$) falling to the null hypothesis non-rejection region of $p \geq 0.01$, it may still be observed that all experimental groups scored lower flexural tensile strength and water absorption percentage scores. The results showed the potential of adding nylon to reduce the water absorption of concrete. Nylon-added samples have the least mean percentage of water absorbed and mean flexural tensile strength score while the control group had the highest mean scores on both tests. Consequently, adding synthetic fabrics lessened water absorption and flexural tensile strength scores. It is recommended to consider other properties under the Roofing Tile Association of Australia (RTAA) and to explore if increasing the sample size will show significant differences in the scores across all sample groups.

Efficiency of organic deodorizer in removing foul smell in shoes

Ben Angelo P. Sebastian (La Salle Green Hills, Philippines); Alejandro Jose C. Javier, N. a. (La Salle Green Hills, Philippines); Ryan Andre Mari Flores Chua and Byron Miguel De Guzman Traje (La Salle Green Hills, Philippines)

Bromodosis or foot odor affects many people around the world. Shoe deodorizers are used to prevent the malodor, but most of the products available may use harmful materials that do not fully eliminate its cause. These products contain substances that degrade the environment (Steinmann, 2016), and pose as a health hazard (Engelund, et al., 2005). The researchers from a private school in Mandaluyong City plan to utilize natural materials (activated charcoal and freeze-dried lemon) in creating a shoe deodorizer. Previous studies have indicated that foot odor was derived from Isovaleric acid, which is produced when *Staphylococcus epidermidis* degrades leucine present in sweat (Ara, et al., 2006). When the bacteria in feet eat amino acids such as leucine, it produces a by-product called Isovaleric acid which causes the foul smell. Various studies have also been made regarding the use of lemon and activated charcoal to reduce foul smell (Otang & Afolavan 2016, Tada, et al., 2016). The researchers will focus on the effectiveness of freeze-dried Citrus limon, (Lisbon variety) in removing malodor. A revised version of the Modified Kirby Bauer disc diffusion test method was done by the Industrial Technology Development Institute, Department of Science and Technology (ITDI-DOST), the prime government research agency in the Philippines. The researchers were able to verify the antibacterial properties of freeze-dried lemons. Results showed that the sample freeze-dried lemons (10mm),

produced complete inhibitory activity with a Total Mean of Inhibition of 12.74mm, and with mild reactivity against the test organism *Staphylococcus aureus*, a common species of the normal microbiota of the skin. It may be concluded from the research that freeze-dried lemons seem to have a good potential to inhibit foul smell, and may be an effective ingredient for a shoe deodorizer. Further studies on the antimicrobial properties of freeze-dried lemons and activated charcoal against *S. aureus* and other skin microorganisms should be made for a more comprehensive report. Factors such as lemon species, parts, form, may also contribute to its effectivity. These findings may support the creation of an effective and organic shoe deodorizer.

The Utilization of the Feynman Technique in Paired Team Teaching Towards Enhancing Grade 10 ANHS Students' Academic Achievement in Science

Ronnel Ian A. Ambion, Rainier Santi C. De Leon, Alfonso Pio Angelo R. Mendoza and Reinier M. Navarro (La Salle Green Hills, Philippines)

Several scholars in the field of science instruction suggested that various challenges can hinder an individual in learning (Chin et al., 2016; Drinkwater et al., 2014; Huang et al., 2015). Furthermore, the help of other people enhances learning. This study applied the Feynman Technique and the practice of paired team teaching to identify the challenges of students in understanding the concept of evolution in a high school Biology class. The researchers tested 20 students from a Grade 10 Adult Night High School class of a private school in the Philippines. The control group took the class without the intervention while the experimental group was introduced to the intervention. Purposive sampling was used based on the student's class standing before the experiment. A ten-item assessment on the evolution of horses was done after the experiment. The study revealed that there seemed to be no significant difference since the t-score of both groups, 0.49, is far from the critical value, 1.75. It is recommended that the intervention should be tested in a larger population, regardless of grade level and a science subject. This is to validate what other variations of inputs can be created from the Feynman Technique.

Edison High School iSTEM Club: A Model for Educational Excellence in STEM

Sunrit Panda, Aditi Deshmukh, Gunjan Adya and Ali Ahmed (Edison High School & iSTEM Club, USA)

Currently, STEM education is a necessity for students at all levels. The iSTEM club represents a model for engaging and teaching students the necessary. Through excellent leadership, intensive programs to educate students, and opportunities to motivate students, the iSTEM club provides enhanced STEM education to students. With these methods, the iSTEM club has benefited the community through book drives, educational programs from elementary school students, and field trips to expand the student body's knowledge. By participating in this club, students are able to reinforce knowledge with hands-on experiences and build up experience in order to perform well in society. As a result, the beneficial interaction between STEM clubs and STEM education structure is revealed.

Who knows more about germs? Adults or first graders?

Rehaam Siddiqui (Pillars Preparatory Academy, USA)

With more people getting sick, it's very important to understand what germs are and how they spread. A common way to determine where germs live is to take a piece of bread and wipe it on some surface, and then measure how quickly mold grows. While this experiment is commonly done, I wanted to extend this idea to

see how well people understand where germs live. My poster includes some background information about germs and how to keep safe from getting sick. Since germs are too small to see, the bread experiment is a good way to easily see how quickly germs can grow. To figure out who knows more about germs, I made a list of questions asking where germs are likely to be. First, I asked a group of adults where they thought germs are. I then asked my classmates (in first grade) what they thought. Then, by comparing the answers against real results that the moldy bread generates, I will answer the question of who knows more about germs: adults or first graders.

An Optimization of Computational Resources Allocation for Multi-MEC and Cloud Networks

Ally Y Du (The High School Affiliated to Renmin University of China, China)

Mobile edge computing (MEC) technology reduces network congestion and enables flexible application deployment. It runs applications and performs related processing tasks closer to mobile customer, so that the network congestion is reduced. Nowadays, MEC is often combined with cloud computing. It has been studied that an optimization of MEC with cloud computing can satisfy not only enough computing power to end-user applications but also with low latency. This paper studies a real-life MEC application on mobile video surveillance and analytics. We started from a simple practical model where the edge node (EDGE) is an AI chip enabled device handling multiple number of video cameras, and transmitting/receiving video streams and signals to a 4G or 5G base station (BS), and then the BS is communicating with the cloud center via optical fiber. In this case, if we offload some functions of EDGE to the cloud center where the computing capability is much stronger, the number of streams, that is, the number of cameras handled, can be increased, and the overall latency could also be improved. With this expectation, we investigate real mobile video surveillance systems used for public traffic and public security, and propose a mathematical system model based on the real mobile video surveillance systems to quantify the relations among the overall system processing delay, the MEC/Cloud offload ratio and the communication channel signal-noise ratio (SNR). We make calculations and obtain the following findings using MATLAB. 1) For any offload ratio, there is a point at which the latency reaches its floor, and thereafter, the effect of increasing SNR is negligible. 2) When SNR is small, the maximum latency decreases as the offload ratio increases, but it requires a much larger SNR to reach the floor point. 3) There is an inflection point which is the minimum overall latency for each given SNR. Overall, to ensure a given latency, offloading more computations up to the cloud center requires less SNR, and thus consumes less energy. These findings suggest that we can design and reach different maximum affordable number of video streams for edge node in a given situation to make the full use of resources. It is possible to improve the system performance in terms of energy saving and efficiency improving by balancing the workload between MEC and the cloud.

Developing an Efficient Remotely-Operated Vehicle to Address Current Marine Issues

Mia Ladolcetta, Suhani Balachandran and Nishtha Dandriyal (Rogue Robotics, USA); Nivedha Srinivasan (nonE, USA)

Rogue Robotics is a nonprofit marine technology development program that gives its members an opportunity to explore and spread knowledge about STEM. The objective of the team is to develop the underwater vehicles that will address the challenging marine issues that society faces today. Every year, the team designs, builds, and tests a remotely-operated vehicle (ROV) to accomplish the underwater missions set forth by the MATE ROV competition. The missions for the 2019 competition tasked ROVs with inspecting dams,

maintaining river water quality, and preserving historical artifacts. Using the competition prompt and video of the mission flythrough as references, the team brainstormed and researched together, then produced 3D computer models of several possible designs. For the frame itself, several materials were researched, and finally, HDPE was chosen because of its high strength, insolubility in water, and high buoyancy. Buoyancy, thruster configuration, and electronics organization were some key elements to consider while designing the setup of the ROV beyond the basic frame. Initial thruster configuration and buoyancy were determined by calculations and then modified with detailed field testing. In addition, different components had to be designed to accomplish the various tasks, such as end effectors to lift objects underwater and a storage bin to carry mission-specific props, which were all first modeled using CAD, printed, and then modified after tests. Equipped with six thrusters, two cameras, and mission-specific devices such as hooks, a metal detection system, and a grout and trout storage box, the ROV was able to accomplish many of the MATE competition tasks. The team scored 105 out of 270 possible points to score, a 10 point increase from the previous year, and completed 10 tasks in the 15 minutes given during the product demonstration. The team was especially proud of the compact design of the ROV and the organization board incorporated into the electronics enclosure, which both helped them earn the maximum score for size and weight constraints. Upon reflection, the team determined some future improvements to be made for the next MATE competition season, like creating a more modular frame and interchangeable mission-specific parts. As of January 2020, the Rogue Robotics ROV for the 2020 competition is still in the first stages of design. Although not all components have to be redesigned, as budgeting and thoughtful design to enable reusability have always been core parts of the challenge for the team, new mission-specific parts of the ROV are currently in the works. From July 2019 onward, Rogue Robotics has changed into an all-girls team, designed to promote girls working in STEM fields. Advocacy has always been an integral part of the team's missions, and the team is proud to be able to reach out to young girls more effectively and encourage their participation in science. The team members are all girls of color and feel that underrepresentation in STEM fields is a major issue, and it is their passion to design innovative solutions to serve the marine world while inspiring the next generation of scientists.

Relationship between Musical Scale, Cello String Length, and Math

Neo Cheng (Clarksville Elementary School, USA)

I play the cello but my intonation is bad because I do not know where to put my fingers. Usually I use a tuner to help me decide where to press the strings, and then I put stickers to mark the locations. In this project, I want to know how to determine the sticker locations using only math without a tuner. First, I used my tuner to determine where to press the string for C, C#, D, D#, E, F, F#, G, G#, A, A#, B, and C. Next, I measured the pressed string length with a tape ruler. Then I calculated the pressed string length ratio to the whole string. For math, I knew there are 12 half-notes within an octave and the length is halved (50%) for each octave. I just needed to find a multiplier that divides the length between 100% and 50% equally. In other words, I needed to find a number M such that $M \cdot M \cdot M \cdot M \cdot M \cdot M \cdot M \cdot M \cdot M \cdot M \cdot M \cdot M = 0.5$. By using a scientific calculator, I found the magic number, M , to be 0.944! This means that for each half-note, the string needs to be reduced to 94.4%, and for each whole-note, the string needs to be reduced to 89.1%.

Object Recognition using TensorFlow

Nahuel E Albayrak (Chesapeake Science Point High School, USA)

Computers can apply vision technologies using cameras and artificial intelligence software to achieve image recognition and identify objects, places, and people. The objective of this project is to capture the image of an automobile as it drives by, identify its model and color, and determine its location, travel direction, and speed. This system can be used to assist law enforcement with vehicle identification in an emergency such as an Amber alert or to detect traffic infractions. For this purpose, we constructed, trained, and applied an object detection model using TensorFlow. First, an image capturing system was built using camera lenses (Raspberry Pi Camera V2-8) and Raspberry Pi (Raspberry Pi 4) small computers. Next, the computers were set up with a software application called TensorFlow. The system was trained to recognize an automobile's model and color by processing a variety of car images. Pictures of different cars were uploaded from Google images and resized highlighting the features of the vehicle. Finally, code was developed in Python to create a universal clock for each camera that recorded the detection time. Five trials were conducted using 2 automobiles available for testing. The cars were recognized by the model with 87 percent certainty in each of the 5 trials. That information was recorded on a table together with the time of capture and the location of the camera. The information from the table was used to successfully identify a specific car's location and speed, with a few limitations. Because of budget restrictions only two cameras were built and two models were used for training. The information from the cameras was not transmitted in real time because wifi or LTE capability are not available at this time. An extension of this research will include multiple cameras, multiple models and real time data transmission.

Rapid and Novel Thickness Identification Methodology For Two-Dimensional MoS₂ and In₂Se₃ Nanosheets Using Optical Microscopy

Darren Y Wu (Charter School of Wilmington, USA); Tingyi Gu (Columbia University, USA)

From the first isolation of graphene in 2004, it has been well documented that the physical, optical, electrical, and thermal properties of two-dimensional materials are highly correlated to their thickness. For instance, material groups such as the transition metal chalcogenides (TMDs) evolve into direct bandgap semiconductors in monolayer form, transitioning to indirect bandgap conductors when their thicknesses are more than two layers, allowing for expanded applications such as phototransistors and photovoltaic devices due to the tunable properties possessed. Therefore, the development of a novel and accurate thickness identification methodology is imperative for the continued study and potential commercialization of two-dimensional materials. In this investigation, an effective, straightforward, and reliable methodology for the thickness identification of MoS₂ and In₂Se₃ nanosheets on 300nm Si/SiO₂ under optical microscopy from approximately single to decuple layer (1L-10L) has been produced. The optical contrast difference values of the atomically-thin nanostructures were collected throughout experimentation and arranged into a valuable standard reference index which was correlated to height number in nanometers. Using this method, the thickness of a substance could be simply and accurately determined without the use of complex instrumentation, experimental setup, and calculation, while also saving time and monetary costs. The method illustrated in the investigation will streamline the research, manufacturing, and application of all two-dimensional nanostructures and further facilitate the advancement of two-dimensional materials towards industrial commercialization.

Study of sample efficiency improvements for reinforcement learning algorithms

Tianyue Cao (Princeton International School of Mathematics and Science, USA)

Machine learning is the study of how programmed algorithms can learn useful knowledge from data automatically. As a sub-field of machine learning, reinforcement learning (RL) focuses on problems that require sequential decision making. In particular, it is about interacting with the environment and taking action according to the environment information sequentially to maximizing some rewards. Reinforcement learning attracts many interests due to its recent successes in robotics as well as playing video games, GO, and poker. However, the fundamental challenges in reinforcement learning still limit its applications to real-world, cost and risk sensitive applications. One major challenge is relatively low sample efficiency in most systems. Sample efficiency is a term used to describe how well the samples are used to train the model. Because of low sample efficiency, it requires a huge number of samples to reach a certain level of performance. In most algorithms of reinforcement learning, methods such as experience replay are used to increase the sample efficiency. In the experience replay, a certain number of samples are saved in a buffer and new data will replace the oldest data in the set. When training, data will be randomly selected from the buffer. However, this will generate the problem of distribution mismatch, as the data chosen this way may not match the current model. In my research, methods are designed so that the samples collected from the past can reflect the current model. That will allow the model to use the data more effectively and thus increase its training efficiency.

A Futuristic Kitchen Assistant - Powered by Artificial Intelligence and Robotics

Riya J. Roy (Ridge High School, USA)

My project is about building a prototype of a futuristic kitchen assistant that is powered by Artificial Intelligence and Robotics. Using Cozmo (an AI-powered robot made by Anki) and Calypso (a language developed by Professor David Touretzky at Carnegie Mellon University for programming intelligent robots), I have built a proof-of-concept futuristic kitchen assistant that shows how the food identification and serving process can be automated. I accomplished this by learning Calypso's rule-based language and its five fundamental laws of computation. Using Calypso's various programming features such as perception, teleoperation, pursue and consume, conflict resolution, speech and hearing, landmark-based navigation, and path planning, I learned how to make Cozmo move around and do intelligent activities, which are demonstrated in my prototype. I designed a model kitchen using a cardboard box. I used the wall templates that had special symbols called "ArUco markers" to help Cozmo recognize kitchen walls and door openings and plan his path accordingly. Once I had the physical model of the kitchen ready, I created a new Calypso program that simulated the model kitchen along with the walls, door openings, the Cozmo robot, and three cubes that represented three different types of food. The program enabled Cozmo to recognize my voice instructions to get a particular food, go to the kitchen through the door opening, pick up the cube that represented the correct food, bring it to the dining room, and then drop it on a plate in front of me. I faced several challenges such as how to make Cozmo recognize my voice, identify the door openings correctly, and move around without hitting obstacles. Eventually, after a lot of testing and debugging, I was able to get the kitchen assistant working and was able to prove that using a robot programming language such as Calypso, a robot can be programmed to perform highly complicated tasks such as listening to voice commands from human beings, navigate from one room to another (i.e., from the dining room to the kitchen), pick up an object (i.e., food), and then navigate and bring the object to another room (i.e., from the kitchen back to the dining room).

In the future, I plan to add more intelligence to the kitchen assistant such as providing the ability for a person to select a dish/recipe on a smartphone app, making the kitchen assistant go to the kitchen, find the right ingredients, follow the instructions in the recipe, make the food, and then serve it to the person.

Saturday, August 1 12:30 - 2:00

Track 1 - Full Papers I

‡ *A three-year retrospective on offering an embedded systems course with a focus on cybersecurity*

Ravi Rao (Fairleigh Dickinson University)

The fast pace of advancement in fields of computer science and engineering creates enormous opportunities for the use and application of computing devices. The internet of things (IoT) constitutes an area experiencing significant growth. If IoT systems are not configured and used correctly, there is potential for widespread disruption and harm due to cyberattacks. Hence, the new generation of professionals in the field of computer technology needs to be conversant with cybersecurity and the design of protection of computer systems. Cybersecurity is not restricted to a specific domain such as hardware or software and needs to address all aspects of operation of computer systems. Consequently, we have found it beneficial to introduce students to cybersecurity through an embedded systems course. Based on three years of teaching cybersecurity to students in an embedded systems course, we observe that students are excited and motivated to participate in hands-on lab exercises. We have taken special care to orient these lab exercises to breaking news articles about developments related to safety and cybersecurity. We also found it helpful to unify multiple lab exercises around a specific target application domain such as healthcare or retail. Our results over a three-year period demonstrate that it is possible to teach essential cybersecurity concepts within a one-semester course to students who do not have prior exposure to this area. This knowledge needs to be expanded upon in other courses, thereby weaving a thread of cybersecurity through the students' educational experience.

Using Text Data Mining to Enhance the Literature Search Process for Novice Researchers

Andres Fortino (NYU & Autonomous Professional Development, USA); Qitong Zhong, Luke Yeh and Sijia Fang (NYU School of Professional Studies, USA)

A literature search can be an arduous process, especially for novice researchers. We have developed a tool that allows a researcher to rank order a list of references that are returned by a keyword-based search engine, based on similarity to known exemplars. This significantly accelerates literature searches by novices. Our research question was: can we produce a text-analytic tool that, when used by an inexperienced scholar, rank-orders a list of references against an exemplar, so that the time needed to find relevant literature is reduced, and the literature survey section of their paper will be superior. An experiment was set up where one course section used the tool to produce the literature review section of a thesis proposal, and the other class used traditional literature research tools. We surveyed both sections to self-report the time used for the literature search. We found some time savings by some of the students using the tool. We also provided blind, randomly selected pairs of completed proposals to SME faculty who teach that same class to assess the quality of the literature sections of the samples. We found that the tool-using section of students reported significantly less time to do the literature search, and the quality of their literature review produced had a significantly higher quality.

Selection and Assignment of STEM Adjunct Faculty Using Text Data Mining

Andres Fortino (NYU & Autonomous Professional Development, USA); Qitong Zhong, Luke Yeh and Sijia Fang (NYU School of Professional Studies, USA)

This paper presents the development and testing of a text data mining tool to assist in the selection and assignment of adjunct faculty to teach STEM courses. The tool scores the resume of a faculty member against course descriptions in a STEM graduate program. The tool returned a similarity score between a resume and course descriptions, which was then used as an indicator of faculty suitability to teach courses in the program. We enhanced the original tool with an improved user interface and deployed it to search for new faculty searches and in the process of assigning courses. A TD-IDF text analytic technique was used for similarity scoring. Our research question was to investigate whether a similarity-scoring tool for faculty resumes against course descriptions would be useful in the search and assignment process to hire faculty to teach specific courses. As part of our methods, we developed a friendly user interface to the existing tool using a student-centered coding contest. We applied the tool to the hiring and assignment of adjunct faculty. We measured success as the processing of a large number of open positions in a relatively short period of time and found a significantly high number of good fits between faculty and their course assignments. We investigated whether the scoring system positively correlated with the courses assigned to them. We successfully filled over 50 unassigned courses with appropriate faculty over a period of three months, where 30% were new hires. In the process, we discovered that the vast majority of the incumbent's similarity scores positively correlated to the courses assigned to them. This generated sufficient confidence that the description scoring system has been integrated as part of our faculty hiring and assignment processes in our programs.

MARREG-MARriage REGistration - for a better cause

Amit Mazumder (Ministry of Electronics and Information Technology, Government of India, India)

MARREG is an eGovernance application software that is accessible through the portal <https://rgmwb.gov.in> by citizens. This citizen centric portal deals with the facets of easing the government business transaction process (GBTP) of handing out marriage certificates that records the solemnisation of marriage between a male and female citizen within the State of West Bengal, in the Republic of India, respecting the laws of the land (governing ACTs and Rules of marriage). This effort towards efficient eService delivery is evolving as an efficient system that entices the use of technology for leveraging effective managerial framework in the field of dissemination of public service through electronic means. The application software and, the entire initiative to register marriages through the online process, seek to empower men and women alike who enter into marital relationship to enjoy benefits linked to social perspectives. The project delivers a certificate of marriage, that's a legal document that, establishes the marital status of a wedded couple. On the social front, such a marriage certificate help the incumbents in getting a fair trial in the event of polygamy, polyandry, grant of citizenship, remarriage, other legal and social angles, as the case may be. Hence, the Hon'ble Supreme Court of India made it mandatory for a couple to register irrespective of the religion they belong to. A certificate of marriage adds value to the social marriage. Thus is this initiative for a better cause.

Integrating a Smartphone-Based Vibration Experiment into an Engineering Course

Musa Jouaneh (University of Rhode Island, USA)

A smartphone coupled with a low-cost physical system can be used to conduct a meaningful at-home engineering experiment that provides an environment for experiential and personalized learning. The objective of this study is to improve students' understanding of the response of a dynamic system through integrating an at-home experiment into a lecture-only class using a smartphone as the measurement system. The paper reports on the use of the linear acceleration sensor in smartphones to conduct an at-home experiment to measure the vibration characteristics of a cantilever beam in a junior-level, systems dynamic course. All students in the class were provided with a spring steel beam and a C-shaped clamp. The students mounted their own phone at the end of the beam, and an app was used to record the acceleration of the beam for three different beam lengths. From the experimental data, the students were asked to determine the damped natural frequency of the beam and compare it to theory. The study was performed over three years with a total of 302 students. Data analysis of the short pre and post quiz conducted with the experiment showed that the at-home experiment had a positive effect on students' understanding of key concepts. Furthermore, written and verbal comments from the students showed that the students valued the learning they got from performing this experiment.

Track 2 - Works-In-Progress I

Experiment design with Galilean beam expanders for magneto-optical traps and the advanced undergraduate laboratory

Jared Matthew Cochrane (United States Military Academy at West Point, USA); Mary Lanzerotti, Corey Gerving, Seth Barbrow and Anthony Dinallo (USMA, USA)

This paper presents a compound lens experiment design, suitable for upper-division undergraduate laboratory courses, in which teams of students constructed and measured the properties of Galilean beam expanders. Skill in developing Galilean beam expanders is useful for undergraduates who will build a magneto-optical trap in a follow-on course. This laboratory experiment was performed by third-year undergraduate students in our applied optics course and provided students with the opportunity to gain knowledge about lasers, lenses, and alignment of optical components prior to their laboratory work building a magneto-optical trap. This paper presents an accessible experimental design to introduce undergraduates enrolled in an applied optics course to beam expanders which they will encounter while designing and building a magneto-optical trap (MOT) in a subsequent laboratory course. Analysis of the experiment is carried out according to typical methodologies in undergraduate experiments.

Exploration of Pedagogical Interventions to Improve the Outcomes of Hispanics in AP Computer Science

Mayra S Bachrach (1000 Morris Ave, USA); Patricia A Morreale and Gail Verdi (Kean University, USA)

A research project underway at Kean University is exploring pedagogical interventions aimed at improving the outcomes of English Language Learners in Advanced Placement Computer Science. English Language Learners are students who come from non-English speaking homes and backgrounds. With the increasing numbers of Hispanic students in many K-12 classrooms, Spanish is the language most often spoken by English Language Learners. Advanced Placement Computer Science teachers will utilize strategies from Sheltered Instruction, an educational model from English as a Second Language and Bilingual education, in their classrooms. The impact

of this approach will be measured by comparing the exam scores of students in the classroom of participating teachers with the 2020 national and state Advanced Placement Computer Science exam scores. Research outcomes of the pedagogical interventions explored will be widely utilized for teaching Computer Science to all English Language Learners, including Hispanics.

Impact of a Free Textbook on an Introductory Programming Course

Tacksoo Im, Hyesung Park, Wei Jin, Rick Price, Robert Lutz, Sonal Dekhane and Na'el Abu-Halaweh (Georgia Gwinnett College, USA)

Rising textbook costs has made students reluctant to purchase them. According to the review of Bureau of Labor Statistics (BLS) data, textbook prices has risen 88% since 2006 and the rate of its increase has been greater than tuition. Even parents do not have the ability to pay for the textbook for years. The high cost of textbooks has led many students to forego the purchase of textbooks and has led to underachievement in many cases. Anecdotaly, the authors have determined that many students are not purchasing the textbook for a programming fundamentals course. In this paper, we present our findings in implementing a free textbook and its impact on students.

A Preliminary Work on Visualization-based Education Tool for High School Machine Learning Education

Abel A Reyes, Colin Elkin, Quamar Niyaz, Xiaoli Yang and Sidike Paheding (Purdue University Northwest, USA); Vijaya Kumar Devabhaktuni (University of Purdue Northwest, USA)

Artificial Intelligence (AI) has become one of the most recurrent topics nowadays, due to its many industrial applications and its wide range of research topics in academia. Within AI, Machine Learning (ML) is one of the most prominent sub-fields, the popularity of which is complemented with its high demand as a professional skill for different industries. In the last few years, teaching ML is thus increasingly common in different levels of education. However, the curricula implemented for several courses or programs to learn ML are not always appropriate for the backgrounds of students, particularly high school students, as programming and complex math experience are usually required to implement ML models and understand the potential of this field. For this reason, it is possible for students to have difficulties with the lack of experience required or expected and to have prior to learning ML topics. In addition, motivation can be affected, as the curriculum does not sufficiently engage the student in the learning process. In this work, we propose a visualization tool to introduce high school students to the ML field, which will be implemented using concepts of gamification and adapting the content of the curriculum without requiring exhaustive experience in programming or math.

SALP: A Scalable Autograding System for Learning Programming - A Work in Progress

Diego Calderon and Erick Petersen (Universidad Galileo, Guatemala); Oscar Rodas (Universidad Galileo & Tesla Lab, Guatemala)

Programming courses can be hard for students, but also for teachers, because of the huge amount of time that takes to manually grade each student's assignment and the different kind of valid solutions. Moreover, there are other problems related to manually grade assignments such as completely objective and homogeneous grading. In consequence, both students and teachers don't get feedback as fast as they should in order to take action and reinforce the topics with lower performance on each assignment. Finally, the increasing popularity of MOOCs makes manually grading no longer viable. To this aim, a scalable autograder system is proposed in order to provide students with faster feedback and help teachers with the evaluation of

assignments. Our proposal can be used for learning different programming languages like Java, Python, C, C# and Ruby.

Using virtual assistant for learning selected topics of Physics

José R Aguilar-Mejía and Santa Tejeda (Tecnologico de Monterrey, Mexico)

With the increase in the use of mobile applications and advances in artificial intelligence, the use of emerging technologies such as chatbots has increased. Given its characteristics, this type of applications are beginning to be used in the educational area, so there is a need to measure its impact and ensure its effectiveness in the learning process. This study implements the use of a chatbot to increase the conceptual understanding of Newton's laws, integrating it into a didactic sequence in conjunction with active learning activities. For the analysis of the data, an exploratory study with a pre-experimental design was carried out on several university physics groups, with a total of 122 participants. Hake's g was calculated to know the gain in the students' conceptual understanding. The results of this study demonstrate that although there is an increase in students' conceptual understanding, the design of the didactic sequence needs to be improved to increase the percentages obtained. Likewise, it is necessary to develop instruments that allow direct measurement of the impact of the use of chatbot on student learning and the selection of a control group to compare the results of students who completed the didactic sequence, with those that take a traditional physics class.

Track 3 - Full Papers II

Math & Crafts, Educational Activities: Ancient Math Methods, Future Directions

Ernesto Vega Janica (IEEE Standards Association, USA)

This paper summarizes multiple numerical systems, math concepts and historical references, and deeply focus on a hands-on exercise where children, parents and educators participate. The main goal of the hands-on experience is to engage our communities around Math, Science and Culture. Kids and adults can have a direct experience with tools, numbers, cultural historical references, and more. This combination of theory and practice should help our kids appreciate technical concepts by their own means and methods, as well as providing a wide-range of learning possibilities for the audience. The intent is to implement some of these "Math & Crafts" activities in local libraries and elementary schools. The research and analysis for this paper is limited to a number of numerical and abacus systems that could offer practical educational models, as well as, hands-on activities for children, educators and parents. The intent is to craft a few practical presentations to promote the use of mathematical analysis, as well as cognitive processes, while teaching basic mathematical concepts to kids. The research also plans to launch these initiatives at the local libraries and expose some of these concepts to a broader audience.

A Hands-on Project to Improve Student Learning Experience in Electronics: Building Ship Storage Room Security System

Wei Yu (Massachusetts Maritime Academy, USA)

Project Based Learning (PBL) approach is known to motivate students to investigate and integrate knowledge of several domains to solve real-life problems. It drives students' intrinsic curiosity to connect isolated concepts to optimize their learning outcomes. Taking the advantages of PBL, a ship storage room security system project was designed and implemented in a junior-level Electronics Lab course at our university. The

purpose of the project was to help students to improve their understanding of electronic element characteristics and their abilities to interpret electronic diagrams, configure and operate of electronic equipment. During the project, students needed to (1) design an electronic diagram that is able to detect ship storage room door open/closed status, trigger an alarm system, and reset the alarm system, and then (2) build an integrated circuit on a breadboard by using various electronic elements following the electronic diagram. Students had to dig into different course contents instructed in class and at the same time learn other new knowledge from external resources, such as internet, industrial documents, etc, to combine them effectively to produce a practical solution. It has been observed that the project has successfully led the students to explore the underlying connections of a variety of electronic concepts from class and new knowledge from external resources reaching their increased understanding of electronics and overall course satisfaction. The student survey results indicate the project has demonstrated strong positive impacts on the improvement of their knowledge and skills in electronic elements, diagrams and equipment.

Course-Specific Model for Prediction of At-Risk Students Based on Case-Based Reasoning

Haris Supic and Dzenana Donko (University of Sarajevo, Bosnia and Herzegovina)

Identifying at-risk students is a crucial step in different learning settings. Predictive modeling technique can be used to create an early warning system which predicts students' success in courses and informs both the teacher and the student of their performance. In this paper we describe a course-specific model for prediction of at-risk students. The proposed model uses the case-based reasoning (CBR) methodology to predict at-risk students at three specific points in time during the first half of the semester. In general, CBR is an approach of solving new problems based on solutions of similar previously experienced problem situation encoded in the form of cases. The proposed model classifies students as at-risk based on the most similar past cases retrieved from the casebase by using the k-NN algorithm. According to the experimental evaluation of the model accuracy, CBR model that is being developed for a specific course showed potential for an early prediction of at-risk students. Although the presented CBR model has been applied for one specific course, the key elements of predictive model can be easily reused by other courses.

A Comparative Analysis of Secondary School STEM Research Programs in a Chinese School and an American School

Xiang Gong and Erik Mohlhenrich (Princeton International School of Mathematics and Science, USA)

Countries around the world are committed to cultivating outstanding talent through STEM education. It is widely acknowledged that authentic STEM research programs are one of the most effective ways to achieve the goals of STEM education. In this paper, we present survey results in the 2018-2019 school year from school-based research programs at Princeton International School of Mathematics and Science (PRISMS) in the US and the High School Affiliated to Renmin University (commonly abbreviated as RDFZ) in China. A factorial MANOVA and a General Linear Model Univariate Analysis were used to test for similarities and differences between students' gains in dimensions of gains in thinking and working like a scientist (WIS), personal gains related to research work (PG), gains in skills (SKILL), attitudes or behaviors as a researcher (ATT), and career and graduate education aspirations (INF). Across both programs, we find significant gains on all variables as students' progress through their research experience. Scores from PRISMS students on WIS, PG, and ATT are significantly higher than those from RDFZ students. SKILL and INF showed significant correlations and thus were analyzed together; PRISMS students also scored higher on these variables. PRISMS 12th graders scored

the highest of all school/grade level combinations. The results of this comparison speak to the efficacy of both programs in achieving the pedagogical goals of STEM research experiences. In addition, variables that could influence the differences are discussed, with particular attention given to the differences in the student population and school in general, number of students per project, and length of the research experience.

Device to Remotely Track and Locate the Position of a Child for Safety

Shamendra Egodawela, Ruwan Ranaweera, Janaka Wijayakulasooriya and Dushan Herath (University of Peradeniya, Sri Lanka)

Parents are always worried about the wellbeing of their children. As per the Statistics Report 2017 by Missing Children Europe Organization, a child is reported missing every 2 minutes. Due to the imminent threat, parents are prone to buy their children mobile phones to keep in touch with them. However, giving a Mobile phone to a child can cause issues including cyber bullying, improper use of social networks, access to mature age and illicit content on the internet and possibly, phone theft. As an effort to tackle some of those issues, this paper proposes a solution which enables parents to call, locate and track their children using a child-friendly mobile device. The common scenario the device would come to play is in enhancing the safety of a child who would travel alone on a typical route; for instance a child who walks from home to school and back. The device can be calibrated to keep track of a typical route of travel. Then, if the device detects some deviation from the usual route, it would trigger a notification to parents. A probability matrix based novel algorithm is introduced to detect route deviation. Design details of the mobile device, along with the details of the route deviation detection algorithm are presented in this paper.

Track 4 - Full Papers III

‡ The Preternship - An Academic-Industry Partnership Model for Early Experiential Learning Experiences in Computer Science Curricula

Matthew Morrison, John Dimpel and Emory Smith (University of Notre Dame, USA)

Herein, we present the "Preternship", an experiential learning method for introducing industry projects in the classroom early in the CS curricula. We conduct surveys of 132 industry members and 39 faculty members, and compare the results to assess opportunity for experiential learning. Then, we present the format and post-program survey results of a Preternship for a 48-student introductory computing course and a 16-student junior/senior level VLSI course, working in tandem with 27 industry Mentors, to demonstrate the potential for implementing this program early in CS curricula. The survey results show significant potential for the Preternship as a model for enhancing student skills in project planning and execution, motivating students to remain in their program, and showcase their technical and leadership potential to employers.

Supporting Engineering Practices in Informal Learning Environments with a Tablet-Based Engineering Design Environment

Nicole M Zapparrata (Center for Advanced Studies in Education, USA)

This paper presents results from WISE Guys and Gals - Boys & Girls as WISEngineering STEM Learners (WGG). WGG is a five-year Advancing Informal Science Learning project funded by the National Science Foundation (NSF). WGG introduces informal, blended STEM engineering design challenge activities to middle school aged youth who attend Boys & Girls Clubs (B&GCs.) As B&GC youth work their design challenges, they practice

engineering design thinking and learn about engineering careers. These youth, who are typically underrepresented in STEM areas, also enhance their STEM knowledge through WGG activity participation. The project developed and is studying brief (75-minute) and long (up to three-hour) blended (virtual and hands-on) engineering design challenges and enhancing WISEngineering, the online platform used to deliver the activities. This paper will present our findings that there is strong evidence that the program is engaging for middle school age youth and that they are learning from the experience.

Design and Development of a SCADA Course for Engineering Undergraduates

Mohammad U. Mahfuz (University of Wisconsin-Green Bay, USA)

In this paper, a design and development of a Supervisory Control and Data Acquisition (SCADA) course for senior level electrical engineering technology (EET) undergraduates have been presented. In this design, a detailed description of the course contents, laboratory experiments, project works, industry visits, and a typical assessment scheme has been presented. As of now, this course has been taught successfully to EET students for 4 years every fall semester since 2016 at the University of Wisconsin (UW)-Green Bay, USA. So far, the course has been very successful in providing the students with an in-depth understanding of a SCADA system and necessary foundational concepts as well as an exposure to practical SCADA systems through several collaborated industry tours. Experiences learnt from teaching this course have also been presented in this paper. A detailed design of the course has been presented in this paper such that the course could also be taught successfully to undergraduates at another academic institution in a similar engineering and/or engineering technology programs.

A social engineering awareness and training workshop for STEM students and practitioners

Aunshul Rege, Trinh Nguyen and Rachel Bleiman (Temple University, USA)

The human element is often regarded as the weakest link in cybersecurity, yet awareness and training efforts focus primarily on the technical aspects of cybersecurity and downplay the relevance of the human factor. One way to exploit this human vulnerability is through social engineering, in which cybercriminals utilize persuasion and manipulation of human behavior and psychology to convince individuals to reveal information, provide access or perform an action. This paper offers a case study on efforts to design and develop a social engineering awareness and training program that was implemented at the 2019 National Science Foundation Cybersecurity Summit using the National Institute of Standards and Technology framework for program development. This program was developed to enhance the ability for individuals in the future and current workforce to protect their organization against vulnerabilities to social engineering attacks, through corresponding awareness and training. The authors share the different stages that are involved in producing a successful program: designing the program, developing the awareness and training material, and implementing the program. In addition, this paper details the challenges and lessons the authors experienced and learned, which can be used as a guide for other practitioners to develop social engineering awareness and training programs.

Mathematics Gamification in Mobile App Software for Personalized Learning at Scale

Chee Wei Tan and Pei Duo YU (City University of Hong Kong, Hong Kong); Lin Ling (Princeton University & City University of Hong Kong, Hong Kong); Ching Nam Hang and Man Fai Wong (City University of Hong Kong, Hong Kong)

The essence of science and engineering lies in the abstract thinking and logical reasoning skills. Advance mathematical topics such as probability and modular arithmetic can be introduced to students at middle or pre-college schools to cultivate their capacity for logical thinking and problem-solving skills as well as gaining mathematical competency required in fields of science and engineering. In this paper, we introduce the idea of mathematics gamification and its application to a mobile app educational software development. We define mathematics gamification as the process of embedding mathematical concepts and their logical manipulations in a puzzle game-like setting aided by computing technologies. This is a form of personalized learning technologies that facilitate learning with peers in a social environment. In particular, we first present PolyMath, a meticulously designed mobile app software used in different learning occasions. The key idea in mathematics gamification is to motivate the users to level up from easy to more challenging game play. Then we describe several mathematics gamification instances in PolyMath, and report its use in an annual Julia Robinson Mathematics Festivals in Hong Kong. The efficacy of mobile app software in a math circle environment opens up new pedagogical ways to teach and learn advanced mathematics.

Saturday, August 1 2:00 - 3:00

Workshops

Smart Home - Programming your first voice-controlled IoT device with MicroPython

Oscar Rodas (Universidad Galileo & Tesla Lab, Guatemala); Yeisson R Chicas (Universidad Galileo, Guatemala); Angel Isidro (Universidad Galileo & Tesla Lab, Guatemala)

Industry 4.0 is growing rapidly worldwide and it is going to be crucial to all kind of industries to survive for the next 20 years. Educational institutions should promote knowledge in the different axis this concept has, like the Internet of Things (IoT), Virtual Reality, 3D Printing, Cloud computing, Robotics, etc. This workshop will let the audience go through the whole process on how to design and build their first IoT device. As a use case the boards we design and assembled were use for a smart home IoT workshop held in my own country. We will share our experience and learning process related to what decisions are crucial since the beginning, what electronic components to use and where to acquire them, what software is best for their first EDA (Electronic Design Automation) tool experience, what manufacturing companies for PCB (Printed Circuit Boards) they can contract and how to assemble their boards if needed. We will also have a short practical session, using MicroPython, to show how easy they can program their own IoT device assembled and how to interact with it by using voice-controlled commands, like Alexa or the Google Assistant. This workshop is intended to be attended by non-experienced audience that is interested to know how to build their own first voice-controlled IoT device. Our case study was held at the Engineering Faculty of Universidad Galileo in Guatemala during various technology events that promoted the methodology "Learning by Doing".

Workforce Partnerships in STEM Education and Computing: A Case Study of Toms River Regional Schools, NAVAIR and the Office of Naval Research

Tiffany Lucey (Toms River Regional Schools, USA); Haidy Oliveira (Naval Air Systems Command, USA); Gaetan Mangano (Naval Air Systems Command - Lakehurst, USA); Marc Natanagara (Toms River Regional Schools, USA)

This hands-on coding across the curriculum workshop will be supported by students, educators and partners from NAVAIR. Participants will have the opportunity to code robots and microcontrollers in a variety of programming languages in an engaging, exciting, supportive and informative learning environment. In the spring of 2018, Toms River Regional Schools was awarded the largest competitive grant in district history—a three-year coding project for high school students funded by the federal Office of Naval Research (ONR). TR:TechReady introduces teachers and students to industry-critical coding languages, most never seen in our schools, and their real-world applications. ONR promotes science and technology applications for the U.S. Navy and Marine Corps, and understands the ways in which district, industry, and naval goals can be aligned. TechReady includes free summer coding camps as well as training, activities, competitions, and access to resources throughout the school year. In this workshop participants will learn about this partnership and the work of NAVAIR and ONR to engage with students and develop local talent as future employees. Computer science, particularly coding, is not only woven into every aspect of our lives, but the process of learning and applying CS and the mindset behind it brings value to every content area and helps students become future-ready problem solvers. Meeting the new NJDOE mandate-- for all high school graduates to study coding starting in 2022-- could be as simple as adding a new course, but we'll explore a more holistic and integrated approach that begins even with our youngest students.

Data Science for Social Justice: An Approach to Broaden Participation

RN Uma and Alade Tokuta (North Carolina Central University, USA); Adrienne Smith and Rebecca Lowe (Cynosure Consulting, USA)

1. Workshop Title: Data Science for Social Justice: An Approach to Broaden Participation 2. Presenters: 1) Dr. R. N. Uma, NC Central University (Expertise: Professor of Computer Science - data science, scheduling and resource allocation with applications to cloud computing, robotics, wireless sensor networks and large logistics problems) 2) Dr. Alade Tokuta NC Central University (Expertise: Professor of Computer Science - image processing, robotics, computer graphics and computer vision focusing on the applications of deep learning to iris and face recognition, wireless networks, mobile computing and machine learning. 3) Dr. Adrienne Smith, Cynosure Consulting (Expertise: Education Researcher - evaluation, implementation, measurement, instrument development and validation) 4) Dr. Rebecca Lowe, Cynosure Consulting (Expertise: Education Researcher - evaluation of STEM education, quantitative and qualitative methods of data collection and analysis to increase diversity in STEM fields) 3. Contact Information of the Lead Presenter: R. N. Uma Email: ruma@ncu.edu Department of Mathematics and Physics NC Central University Durham, NC 27707 Ph: 919-530-6236 4. Learning Objectives: 1) Student Participants: • Introduction to the field of data science. • Insight into how STEM could be used as a vehicle to tackle social justice issues. 2) Educator Participants: • Introduction to the field of data science. • Insight into how STEM could be used as a vehicle to tackle social justice issues. • Ideas for getting more underrepresented minority students interested in STEM. • Ready-to-implement project modules, that could be incorporated as a project in a relevant course, an after-school activity, an extra-curricular activity or a club. 5. Target Audience: Educators and Students (High School and

above). 6. Workshop Overview: Underrepresentation in STEM is a tenacious problem. Despite research identifying and addressing many of the prerequisite factors for recruitment and persistence in STEM (e.g., self-efficacy, sense of belonging), underrepresentation remains a problem. Best practices in teaching pedagogy stresses the importance of incorporating personally relevant contexts and scenarios to maximize student engagement. Our ongoing project (funded by NSF HRD#1912408) takes this pedagogical approach one step further by going beyond making STEM feel personally relevant to signaling a call to action by grounding instruction in social justice. Situating STEM as a vehicle for revealing and unpacking social inequities and promoting social justice, is a novel approach to STEM instruction and one that is likely to have broad appeal for many underrepresented groups in STEM. Data science, a burgeoning STEM field that focuses on applications across many areas in society (e.g., health care, law enforcement), offers the ideal starting point for highlighting to students how STEM provides a meaningful avenue for pursuing social justice. In this workshop, participants will be led through an interactive hands-on activity to explore a real data set pertaining to a social justice issue, for example, gun violence or fatal police shootings. The workshop will proceed as follows: 1) participants will discuss the social justice issue to gain an appreciation of the problem; 2) participants will discuss methods of tackling this injustice along with how data can be used to inform this process; 3) we will introduce a web-based open-source data analysis tool: CODAP- Common Online Data Analysis Platform (<https://codap.concord.org/>); 4) the participants, with our guidance, will visualize the data using CODAP; 5) we will also provide template R code for those who would like to visualize the data using R. 6) we will use R to analyze the data to gain an understanding of the importance of the features (or variables) and to discern those features that significantly contribute to this social injustice; 7) the participants will discuss how this new insight, gleaned from the data, can be transformed to address the social injustice either through policy changes or as a tool to inform training of the stakeholders; 8) the workshop will end with participants sharing their ideas of how they would adapt this project and/or how to improve this project. Technology Requirements: This workshop requires a computer lab with internet access or participants need to bring their own laptops. Participants who would like to use R are encouraged to bring their own laptops. We will help participants install RStudio on their laptops prior to the workshop. RStudio is free and can be downloaded from: <https://rstudio.com/products/rstudio/download/>

Social engineering for multiple undergraduate STEM fields

Aunshul Rege, Rachel Bleiman and Mollie Ducoste (Temple University, USA)

(2) Name, affiliation, and expertise of each presenter Aunshul Rege, Temple University Dr. Rege is an Associate Professor with the Department of Criminal Justice at Temple University. Her cybersecurity research projects on adversarial decision-making and adaptation, organizational and operational dynamics, and proactive cybersecurity are funded by the National Science Foundation. She has taught several undergraduate hands-on course projects in social engineering. Dr. Rege offered a 3.5 hour workshop on social engineering at the 2019 NSF Cybersecurity Summit, which was very well received. Rachel Bleiman, Temple University Ms. Bleiman is an undergraduate honors student at Temple University majoring in Criminal Justice with minors in Computer Science and Psychology. Her areas of interest include cybersecurity, privacy and surveillance. Ms. Bleiman helped plan, organize and co-lead the social engineering workshop at the 2019 NSF Cybersecurity Summit with Dr. Rege. She is currently working as a undergraduate research assistant on Dr. Rege's NSF CAREER grant which examines adversarial decision-making, adaptation, and group dynamics as cyberattacks unfold. Mollie Ducoste, Temple University Ms. Ducoste is a PhD student in the Criminal Justice Program and Temple University. Her areas of interest include community violence and community partnerships. She is currently

working as a graduate research assistant on Dr. Rege's NSF EAGER grant looking at a mixed-methodology approach using social and computer science to understanding adversarial behavior in cyberattacks. (3) Contact information of the lead presenter Aunshul Rege: rege@temple.edu (4) Learning objective(s) This workshop will introduce attendees to the topic of social engineering, tactics and psychological persuasion techniques used, SE playbooks, and relevance to cyberattacks and cybersecurity (5) Target audience Educators, students, industry, government, and anyone who is interested in human factors in cybersecurity (6) An overview of the workshop (428 words). Social engineering (SE) is defined as any act that influences a person to take an action that may or may not be in his or her best interests and is the method of utilizing human behaviors to engage in cybercrime. SE is a technique used to conduct reconnaissance, often the first stage of a cyberattack. Previous research indicates that adversaries, such as nation states and organized crime groups, spend a good portion of their time (50-75%) on reconnaissance. Nearly 70% of US organizations experienced SE attacks in 2017, costing the country approximately \$2.76 million and each instance taking approximately 20 days to resolve. Cybersecurity experts agree that the human factor is the weakest link in cyberattacks, making SE a major concern for cybersecurity. This workshop will introduce attendees to the SE topic, tactics and persuasion techniques used, SE playbooks, and relevance to cyberattacks and cybersecurity. The workshop will share social engineering case studies. Attendees will also engage in a safe, ethical, and fun hands-on social engineering activity then share their experiences. The workshop will end with an interactive discussion where attendees will share thoughts on possible SE prevention and mitigation measures, implementing SE training and education at their respective organizations, the role of ethics in training and education, and a Q&A session with workshop organizers.

Logic Models: A Tool for building successful interconnected STEM programs

Deborah Hecht (CUNY Graduate Center & Center for Advanced Study in Education, USA); Nicole M Zapparrata (Center for Advanced Studies in Education, USA)

(1) Logic Models: A Tool for building successful interconnected STEM programs (2) Name, affiliation and expertise Dr. Deborah Hecht: Director of the Center for Advanced Study in Education, CUNY Graduate Center, Expertise: PhD in evaluation and a full-time evaluator with over 30 years' experience evaluating STEM initiatives; Have evaluated numerous NSF funded interconnected STEM learning projects Nicole Zapparrata: Research Associate at the Center for Advanced Study in Education. Expertise: A doctoral student focusing on educational research and evaluation with a strong background in quantitative data analysis (3) Contact information: Deborah Hecht, CASE/CUNY, 365 fifth Ave, Suite 3301, NY NY 10016, dhecht@gc.cuny.edu. 212 817-1834 (4) Sessions Learning Objectives: To provide an understanding about how a strong evaluation plan can help facilitate program success. Specific learning objectives for participants a. Understand what a logic model is and how it can help you conceptualize your project goals b. Understand the importance of a logic model c. Understand how to construct a logic model in a format that is communicative to others d. Know how to construct a simple logic model e. Be able to connect own goals to a logic model f. Begin to develop a logic model for your program g. Know where to access additional materials (5) Target audience: Anyone managing an interconnected STEM program that would like to use evaluation data to help guide program decisions. Workshop will be especially useful to participants who want to create or refine a logic model and theory of action for their own work. (6) Workshop overview: The workshop will be a combination of information sharing and hands-on work by participants. The facilitators will discuss how logic models provide a roadmap for understanding a project and assuring that the goals and anticipated outcomes of a program are reasonable given the proposed activities and available resources. The group will consider and learn about the importance

of having a logic model when designing and/or evaluating a program. The group will also learn that logic model construction is a continuous process and about the importance of updating the model as the program matures. During the workshop several engaging activities will help participants develop an understanding of how they can create a logic model that is unique to their program. The group will be provided with examples of different types of logic models with varying complexities. They will work with templates individually or in groups and leave the session with an initial logic model and tools and examples for building a more complex model.

Future Learning Workforce

Bruce Hecht (Analog Devices, USA)

This decade is predicted to bring significant change in many aspects of human and machines living together. How will this affect human work? What is the role for learning and the future? We will explore learning, for young people entering the workforce and for adults and their future growth. How will machine learning, specialized artificial intelligence, and general intelligence be integrated into our lives? The workshop will be interactive with a symposium introduction presenting multiple perspectives and a working experience session simulating and exploring the future that we may be bringing into being. Systems and models of humans and machines in the context of the world economy, as well as emerging changes from nanoscale to planetary scale and beyond. "To be a teacher is to be a prophet" and the changing nature of learning. What are the future expansion of human capabilities that are emerging. Proposed Workshop Program: 1. Motivation towards future learning 2. Symposium perspectives 3. Virtual future experience

After College General Physics: A Renewable Energy Primer

Jorge Santiago-Aviles (University of Pennsylvania, USA); Gerri Light (Western Governors University, USA)

WORKSHOP AIM: Of the multiple problems threatening humans, the three most prominent are difficulty acquiring food, energy, and overpopulation. It is our responsibility to acquire enough information to help seeking solutions to these problems. LEARNING OBJECTIVES: In this workshop we are dealing with some fundamental concepts related to energy, in particular renewable energy, where no combustion of fossil fuel or carbonaceous materials take place, therefore, with no generation of greenhouse gases with its consequential global warming. The student will be able to relate how the principles of renewable energy system are easy to understand, reliable (distributed energy sources), and efficient ways of satisfying the overall energy needs for our home, neighborhood and / or perhaps our town, all this while respecting our environment and life in our planet. TARGET AUDIENCE: This workshop is aimed at undergraduate freshman or sophomores, those who have taken a course in general physics, although it can be implemented with High School seniors who have taken physics. OVERVIEW: We discuss some aspects of the sun as the only source of energy in our planet. How in the sun surface as a result of nucleosynthesis, electromagnetic radiation (light) is emitted into space until intercepted by the earth and how the brighter the light source, the greater the amount of energy radiated. There are two ways the Earth surface receive radiation from the sun, namely beam radiation, and when the light photons interact with gases or dust in the atmosphere (diffuse radiation). We will discuss the physics of photo-voltaic phenomena (PV), namely materials and devices capable of converting power in sunlight into electrical power. We will discuss the abundance, processing and basic physics of Silicon, doping, and the creation of junctions to forms diodes. The PV cells are a collection of diodes, how they transduce light into electric power, and the maximum power produced. The concept of energy bands and the band gap in crystals.

How when a photon is absorbed by a Si solar cell forming an electron-hole pair, electric current is produced. The solar cell equivalent circuit, the concept of short circuit current and open circuit voltage and the maximum power. That modules (or panels) are collections of interconnected cells, and arrays, collections of interconnected modules. The concepts of the I-V (current-voltage) and P-V (power-voltage) characteristics, maximum power point, as well as the fill factor. Following, we discuss some concepts in charge storage, such as electrochemical cells, batteries (Pb-acid and the Li-ion), the problems of under and overcharging batteries, and the Charge Controller (CC). At this point we engage the different types of CC (on-off), PWM (pulse width modulation) and MPPT (maximum power point tracking), and their operating modes. How the usual stand-alone PV system (using battery storage) avail themselves with inverters capable of converting DC power into AC, as most household appliances are AC loads. There are grid-tied PV systems, that utilize no storage devices (batteries), and therefore no CC. In their case, they use micro-inverters (convert DC to AC at the grid frequency). The PV systems comprise a large part of the renewable energy systems implemented worldwide, as they are the less geography dependent and more reliable, although slightly more expensive than others on the average. The second in the hierarchy of implemented renewable energy systems is the EOLIC or wind turbines. Note that wind currents result from the sun radiation preferentially heating the atmosphere in the tropics, carrying by convection heat energy to higher latitudes, and therefore highly geography dependent. A wind turbine is fundamentally a Dynamo (DC) or alternator, with airfoil shaped blades attached to the rotation axis. The airfoil shape of the blades produces a force in the direction of rotation (lift) transducing (changing) the kinetic energy of wind motion into rotational energy and through the dynamo, into electrical energy. The third renewable energy system discussed is the low head hydroelectric system. Note that water has 1000 times the density of air, therefore larger gravitational potential energy besides the kinetic energy of its motion as it flows. To transduce both the gravitational potential and kinetic energy of water, one needs a turbine consisting of a rotating wheel (the runner) coupled to an electrical generator (dynamo or alternator) as well as the water feeder pipes. For substantial head (vertical distance through which the waterfalls) "impulse" runners are utilized. There is a virtue in having small relatively isolated electric power generating centers (distributed energy resources), it enhances the grid (electric power network) reliability and ease of maintenance.

Face & Object Recognition using Machine Learning on a Raspberry Pi using a Webcam

Shubhendu Das (STEAM WORKS STUDIO, Princeton, NJ, US, USA)

Like the last 3 years of IEEE participation in this event, Steam Works Studio is interested in having a Table for interactive demonstrations of highly experiential interesting DIY electronics, Robotics, AI & ML projects for the benefit of K-12 students, school & university administrators as well as general audience. In addition, we would be very happy to show the mechanics and intricacies of how to use Python, Machine Learning, Haar Cascades and train any object to be recognized using a low compute device like Raspberry Pi and a Web Camera. Learn the principle and technique that makes this possible. Everyday there are hundreds of new applications that are being developed using the above technique and the best part is that it is simple to do! Hopefully some K-12 students can learn these basics and use them for some interesting product idea, use to better humans with some disadvantage, or build sustainable and green applications.

Saras-3D comprehensive 3D stereoscopic virtual hands-on VR/AR learning experience

Bipin D Dama (Saras-3D, Inc., USA)

The demands on students and the knowledge to be assimilated are increasing, however, time allocated does not change. The real world is in 3D and learning aids are in 2D, creating a barrier in understanding subject matter efficiently. Saras-3D has created app, content and associated hardware where STEM subjects are taught through 3D virtual hands-on experience and interactive gamification-based content including 3D video lectures, detailed explanations, quizzes, and practice tests. We aim to open the third dimension using 3D technology to help students learn efficiently and develop a deeper understanding through teacher-guided learning as well as self-guided discovery. By creating interactive gamification-based learning, we can help students to increase interest and retention of topics that they find particularly challenging to grasp. When time is constrained, 3D virtual reality technology helps in understanding the fundamental concepts, simplifying the complex and impossibly large amounts of information into a coherent form. Our vision is to provide tools that can encourage and create lots of great innovators and problem-solvers for society by sparking their interest in science and mathematics. In this workshop/information session, we will demo our products and explain in detail the workings of the same. <https://youtu.be/qCjHHMPJsog> Presentation by Bipin D. Dama, Founder & CEO, Saras-3D, Inc. <https://www.linkedin.com/in/bipin-dama-70708b1/>

ReadyAI Workshop on AI-Powered Robotics and Project Based Learning

Roозbeh Aliabadi (USA)

The goal of the workshop is to give students interested in AI a chance to experiment hands-on with real AI algorithms for computer vision, face and emotion recognition, speech recognition, and generation, landmark-based navigation, and path planning. In the first part, students will be introduced to AI + ME (online AI experience on % big ideas in AI). They will be introduced to the Calypso for Cozmo programming framework (see <https://Calypso.software>) and the Cozmo robot. They will further use these tools to develop preliminary interactive demos or games that highlight how artificial intelligence can make our lives better. The session will be led by David Touretzky, a Research Professor in the Computer Science Department at CMU and Roозbeh Aliabadi, CEO of ReadyAI and Yang Chan Program Director of Ready AI. Ready AI will supply the robots and other equipment needed for the workshop, and provide a staff member to assist with operations. Target audience: This activity is designed for undergraduate CS and ECE students, K12 teachers and K12 students who are curious about AI. We will place particular emphasis on attracting women and members of underrepresented groups.

Experiential Learning Using Free Web Tools and Services - Assessing Impact on Engineering Students' Academic Achievement and Self-Efficacy

Muhammad Safeer Khan and Mohamed Ibrahim (Arkansas Tech University, USA)

The workshop is designed to introduce freely available web tools and resources to engage students in experiential learning. We will present examples of the use of these tools and resources in engineering and technology curricula. We will also focus on assessing the impact of experiential learning approach on students' academic achievement and self-efficacy. The workshop is also intended to achieve the following specific learning objectives: 1. Become familiar with the use of freely available web tools and resources to engage in experiential learning. 2. Addressing students' four-stage model of experiential learning in Engineering courses

(a) have some form of hands-on active learning experience, (b) reflect on this experience, (c) abstract general rules or concepts from it, and (d) actively experiment with applications of these new concepts, generating new concrete experiences through repetitions of the cycle. 3. Understand approaches to investigate impact of experiential learning on students' academic achievement and self-efficacy through empirical data collection and analysis.

200 years of Electro-Magnetism

Helena Rittenhouse (Princeton University EPICS, USA)

This workshop explains electromagnetism in the words of Princeton Professor Joseph Henry (1797-1878) about the history of electromagnetism. This year marks the 200th anniversary of Oersted's discovery of electromagnetism and using Joseph Henry's paper would be a great way to connect to Princeton history. The focus of this workshop would be to teach the history of electromagnetism through hands-on, interactive exhibits that can easily and affordably be recreated in the classroom. My proposed activities are all interactive, engaging recreations of original experiments. My name is Helenka Rittenhouse and I am a sophomore at Princeton High School. I have been participating in Professor Michael Littman's Engineering Projects in Community Service (EPICS) course at Princeton University for the past year. Specializing in Joseph Henry's electromagnetic discoveries, we conduct outreach programs at schools, libraries, and in the community teaching and showcasing the works of Joseph Henry and other significant scientists in the history of electromagnetism. My 90-min workshop, intended for STEM educators, would consist of a short PowerPoint presentation followed by five stations of interactive, engaging activities, each exploring significant historical discoveries in electromagnetism. Each station will have easily and inexpensively replicable experiments for classroom demonstration.

Saturday, August 1 3:00 - 4:30

Track 5 - Full Papers IV

Experiences Toward An Interactive Cloud-Based Learning System for STEM Education

Bharath Kumar Samanthula, Mirza Mehran, Michelle M. Zhu, Nicole Panorkou and Pankaj Lal (Montclair State University, USA)

The digital technology plays a vital role for improving student learning and engagement. This is especially true in STEM education where teaching scientific concepts for K-12 education requires engaging platform to encourage inquiry-based learning, and it has been shown that the use of computer simulations can increase student achievement and their interest in STEM. In this paper, we present an interactive cloud-based web system that enables teachers in middle schools to effectively teach earth and environmental science using interactive simulations. To achieve on-demand accessibility and high reliability, our system is hosted on Amazon Elastic Compute Cloud platform that allows users, with an Internet connection and a Web browser, to access the course and do assignments. Additionally, we demonstrate teacher-role's functionality regarding managing course content, identifying low-performing students and achieving improved student learning outcomes. With the seamless integration of interactive simulations, user-friendly interfaces and transparent functionalities, our system aims to make learning more fun and engaging. Teachers who have used our system found it to be very helpful in engaging their students.

Behavioral Simulation Educational Framework for 2-Terminal MTJ-based Analog to Digital Converter

Gustavo Camero, Soheil Salehi and Ronald DeMara (University of Central Florida, USA)

The emergence of advanced non-uniform Compressive Sensing (CS) signal processing techniques and spin-based devices has led to the development of novel Analog to Digital Converter (ADC) architectures. Herein, a novel interactive simulation framework is developed to provide widespread access to the ADC architecture designed using commercially-available 2-terminal Magnetic Tunneling Junction (MTJ) devices. The proposed ADC simulation framework utilizes CS techniques to provide insights for educational and technical purposes. The proposed framework provides simulation results spanning from the energy consumption required by each sample and MTJ device to the switching behavior of each MTJ device. Additionally, the results demonstrate the type of signal used along with the bias voltage required to switch each MTJ device. However, currently, 2-terminal MTJ devices and advanced signal processing techniques are not part of the Electrical and Computer Engineering undergraduate curriculum. To mitigate this challenge, the proposed framework has an educational resource site companion to distribute the interactive tool and further provide insights into the modeled Spin-based ADC by showcasing the research it was based on. Finally, the educational resources site also includes video tutorials to further engage the students and teach undergraduates the fundamental behavior of MTJ devices and utilization of the interactive simulation framework.

Interdisciplinary Collaboration Approaches on Undergraduate Virtual Reality Technology Projects

Eric Nersesian, Margarita Vinnikov, Jessica Ross-Nersesian and Michael J Lee (New Jersey Institute of Technology, USA)

Educational approaches must keep pace with the rapidly advancing state of technology so that students have the necessary skill sets for the modern workforce. Computer science education presents an interesting cross-section of challenges to STEM education to explore the effects of alternative teaching methods. Our undergraduate program has been working on these educational challenges for several years. We have found project-oriented studio classes integrating computing and design students with collaboration on emerging technology projects are leading to positive outcomes. The collaboration discussed in this paper involved an instructor from a VR computing course in our university's College of Computing and an instructor from a VR interaction design course in our university's College of Architecture and Design. The collaboration was set up in such a way that students from both classes could work with each other, while both instructors were able to meet their objectives. We present this cross-class collaboration method along with student surveys and final presentation results. It is a necessary class structure to successfully educate future developers and designers, and we wish to share our experiences with the larger STEM educational community.

Suspended Load Swing Stabilization

Thomas R Aldhizer, Austin Morock and Kristina Hughes (The United States Military Academy, USA); Mary Lanzerotti (USMA, USA); Suzanne Christoff, Susan Lintelmann and Jacob Capps (The United States Military Academy, USA)

This research proposes an interdisciplinary collaboration to improve hoist stabilization for medical evacuation and successful rescues. This paper would include the collaborative efforts from a diverse range of fields to include Systems Engineering, Mechanical Engineering, Physics, and the Special Collections & Archives Division of the United States Military Academy Library. The research objective of this effort is to create an algorithm

which could limit the displacement angle of a suspended individual below a helicopter. This would be accomplished by changing the relative length of the cable at different points within the swing of the slung mass. This could all be done while reeling in the hoisted individual to the helicopter by changing the rate at which the hoist is lessening its cable. Elements of the mathematical principles that this research is built on are illustrated through Edgar Allen Poe's application of the pendulum in his short story "The Pit and the Pendulum". Poe was an individual who attended, but did not graduate from, USMA; however, his education at the Military Academy and his subsequent writings are the birthplace of this research endeavor. It is a multi-semester goal, and this paper will present an initial proof of concept.

Pre-college Computer Science Initiative for Augmented and Virtual Reality Development

Eric Nersesian and Adam Spryszynski (New Jersey Institute of Technology, USA); Tracy Espiritu (Passaic County Technical Institute, USA); Michael J Lee (New Jersey Institute of Technology, USA)

New curriculum initiatives are growing to meet near-future, industrial demand for computer science graduates with Augmented and Virtual Reality (AR/VR) development knowledge. Universities are often at the forefront in developing these curricula to help prepare their students for industry jobs. High schools wanting to offer college-level courses for their students typically work with local universities to adapt courses for their students' needs. This paper presents such an effort along with results from a student survey showing the successful implementation of college-level courses through training of high school teachers. Decisions of the program structure from both the collegiate and high school perspectives are discussed along with an explanation of events to help other educational institutions interested in expanding their own programs. The curricula from this study are available for public use via website and adapt as needed to meet the emerging employment needs of their students pursuing academics and jobs in AR/VR.

Track 6 - Works-In-Progress II

Systems Thinking and STEM/Technical Training: How to Use a Holistic View to Prevent End-to-End System Problems

Dwight Bues (SAIC Corp., USA)

I was challenged by Rocky Avvento and Eric Sudano at the 2019 IEEE ISEC conference to expand their discussion of Systems Thinking (targeting K-12 students) and mine regarding STEM Education to cover how these holistic design methodologies apply to Vocational - Technical Training. A holistic design process is utilized by engineers subconsciously, but is one of the most important things to teach to young technical students. This paper will present several operationally-relevant models of "systems" to help the reader understand the concept and, potentially, use it in his/her own designs. The Challenge is that there must be a way of looking at Systems that gives the Engineer/Technician a broad view of its overall working constraints and the interactions of its component parts. Systems Thinking is just that type of technique.

Improving method of instruction in classrooms

Sanish Rai (West Virginia University Institute of Engineering, USA)

During lecturing, a whiteboard is the instructor's most used tool. While the instructors provide lecture slides to students, the whiteboard contains more valuable information which all are erased as the lecture progress to make space for new content. In this work, a study is performed by using an iPad and Apple pencil as a digital

whiteboard and marker. A digital tablet allows to provide all the notes written during a lecture to be saved and provided to students. The technology is used in the classroom to be used as a cheaper and better alternative to the instructor's computer and whiteboard without need of any new software or hardware requirements. The study showed that iPad and apple pencil could be an effective instructor tool if the instructor can utilize available iPad apps.

Improving computer science lab feedback methods

Sanish Rai (West Virginia University Institute of Engineering, USA)

In computer science programming courses such as Java, C, Python, C++, the computer science (CS) lab plays the most significant role in helping freshmen students to learn the coding for the first time. In the labs, students work on some programming assignment problems and submit them on an online platform to be graded by instructors. The labs are designed to get student hands-on coding and implement the programs in the computer, however, the feedback is received after a week or many of which are ignored by the students. As such, in this work, a one-on-one grading feedback methodology on completion of the program was implemented. Along with feedback, instructors would ask various questions to students related to the problem to understand their knowledge, thinking process and at the same time, enhance the communication skills of students. A quantitative study of the process using survey data showed that this method had a positive impact on students without causing any additional burden on instructors.

STEM Leadership and Training for Trailblazing Students in an Immersive Research Environment

Marisel Villafañe-Delgado, Erik Johnson, Marisa Hughes and Martha Cervantes (Johns Hopkins University Applied Physics Laboratory, USA); William Gray-Roncal (Johns Hopkins University Applied Physics Laboratory & Preparation Meets Opportunity Foundation, USA)

Educating the workforce of tomorrow is an increasingly critical challenge for areas such as data science, machine learning, and artificial intelligence. These core skills may revolutionize progress in problems such as healthcare and precision medicine, autonomous systems and robotics, and scientific disciplines such as neuroscience. Skills in data science and artificial intelligence are in high demand in industrial research and development, but we believe that traditional recruiting and training models in industry (e.g., internships, academic connections) are not serving the needs of the diverse populations of students that will be required to revolutionize these fields. Our program, CIRCUIT, targets trailblazing, high-achieving students who are facing barriers in achieving their goals and becoming leaders in data science, machine learning, and AI research. Traditional recruitment practices often miss these ambitious and talented students with non-traditional backgrounds, and these students are at a higher risk of not persisting in research careers. In the CIRCUIT program we recruit holistically, selecting students based on their commitment, potential, and need. We designed a training and support model for our internship, consisting of a compressed data science and machine learning curriculum, a series of professional development training workshops, and a team-based robotics challenge. These activities support trailblazing students developing the skills needed for dynamic, team-based engineering teams of the future.

A Study of Localization Methods to Help Elderly Patients in their Home Environments

Akbar Ali (University of Virginia, USA); Jennifer Suon (Towson University, USA); Muhammad Ali Yousuf (Johns Hopkins University, USA)

Patients with various movement hampering illnesses that are kept in hospitals are at low risk of getting injured as they are constantly under strict observation. However, once these patients move into their homes, it becomes difficult to monitor them and/or warn them of potential hazards. For example, Chronic Obstructive Pulmonary Disease (COPD) is a group of progressive lung diseases that obstruct airflow. It affects millions of adults in the USA alone, with a world estimate of 64 million by the World Health Organization. COPD patients are tied to their oxygen tanks via pipes that are attached to their mouths for breathing. Older individuals living at home who have a system set up with these oxygen tanks can be exposed to many different problems such as walking too far away from the tank, tripping over the plastic pipes, etc. Most of these patients have limited resources to invest on expensive tracking devices. In order to solve some of these problems, one must first be able to reliably locate them and keep track of them at all times. The objective of this work is to provide a comprehensive, multi-sensor platform which can be reliably installed at homes. We explore a variety of low cost tools and techniques available. This includes satellite tracking of cell phones, ultrasound, laser range finders, iBeacons, etc. We also discuss some of the fancier tools on the horizon, which may soon be available for household applications.

Track 7 - Full Papers V

Out-of-school Time STEM: Teach Programming Using Python for High School Girls

Chaoyi Wang and Michael Frye (University of the Incarnate Word, USA)

In the next decade, there is an enormous increase in job openings in the fields of science, technology, engineering, and mathematics (STEM). The early recognition of STEM talent is necessary to meet the demands of STEM labor force in the United States. Thus, it is essential for educators to apply diverse teaching methods to provide meaningful programming learning to students at High School level. In this study, the researchers designed an eight-session Python programming curriculum for high school girls and implemented in Girls in Engineering, Mathematics, Science (GEMS) STEAM program in San Antonio, Texas, USA. Through the analysis of pre- and post- surveys and interviews, the results showed that the Python programming course have created a fun and interesting learning environment. This eight-session course effectively expanded students' previous knowledge about programming and increase their interests in computer science (CS). In the process of learning, students developed the problem-solving skills. This study suggested that it is important for educators to create a fun and interactive learning environment when teaching programming for high school girls. There is a need of more efforts and opportunities which needs to be provided for girls to increase their participation in CS.

Encouraging Higher Education STEM Careers Through Robotics Competitions

Rodrigo A Canek (Universidad Galileo, Guatemala); Pablo A Torres (Student Universidad Galileo, Guatemala); Oscar Rodas (Universidad Galileo & Tesla Lab, Guatemala)

Over the years, statistics from different universities have shown that not enough professionals graduate from higher education careers focused on Science, Technology, Engineering and Mathematics (STEM). For the last 5 years, a series of university outreach programs in Guatemala have been created promoting robotics,

technology and engineering. These programs are focused in students from elementary to high school, where the participants are able to experience with robotics, while developing their STEM and soft skills and having fun. As a result of the outreach program of Universidad Galileo, two Robotics Competitions were held in Universidad Galileo campus; later evolving to three National Robotics Competitions, three participations in First Global Challenge (FGC) and two participations in Robomatrix Continental. After different surveys distributed and several feedback meetings with former National Team members, we can ensure that at least 75% of these students will be encouraged to follow a higher education STEM career or work in a STEM related job. Our filtering process has been improved to choose our international team members from a bigger pool and in a more accurate way. Our initial participation started with 8 students selected from a pool of 100 students and the last participation with 18 students from a pool of more than 2,400 students. We have proven that using multiple courses, MOOCs, workshops and the possibility to participate in national and international competitions encourages students to choose a higher education STEM related career in the near future.

Development of low-cost IoT devices to encourage STEM skills in Guatemalan environments

Yeisson R Chicas (Universidad Galileo, Guatemala); Angel Isidro and Oscar Rodas (Universidad Galileo & Tesla Lab, Guatemala)

Industry 4.0 was first introduced in Germany in 2006. As leading countries of this initiative, we can mention various European and Asian countries and the United States. The main axis that Industry 4.0 has are Internet of Things (IoT), Virtual Reality, 3D Printing, Cloud Computing, among others. Guatemala is becoming a technology hub country. Various web development or BPO companies have migrated their technology departments to our country because people have well developed STEM skills. Their main activities involved web development, infrastructure and help desk collaborations. However, hardware development is not an economic pillar to develop our country yet. In Universidad Galileo we created academic and outreach programs based on IoT to change the mindset of young students and professionals to become technology producers and not only technology consumers or users. Our two-year research, the workshops developed, and the feedback obtained by participants in our technology events ensures that our STEM programs are building the correct skills in people to help develop Industry 4.0 in Guatemala.

Designing the curriculum for a minor in Cyber Criminology

Rajesh Prasad (Saint Anselm College, Manchester, NH, USA); Liana Pennington (Saint Anselm College, USA)

We are living in an age of growing cyber crime and the costs associated with it. With more and more people and devices being connected through the Internet, there are plenty of opportunities for new kinds of criminal activity as the Internet provides cyber criminals with anonymity and global reach. According to the FBI, in 2018 the Internet Crime Compliant Center (IC3) received 351,936 complaints with total losses exceeding \$2.7 billion. The threat of cyber crime is real and pertinent when the Internet is intertwined with our everyday lives. We must prepare today's undergraduate students, tomorrow's future workforce, to fight this growing threat of cyber crime. If we do not prepare today, we will be vulnerable tomorrow. This paper details our experiences in developing and implementing an interdisciplinary minor in Cyber Criminology. The minor is designed for students who are interested in learning about cyber crime from the dual perspectives of computer science and criminal justice.

Influencing factors to choose STEM areas: The case of Mexican strongly STEM-oriented high school students

Angeles Dominguez (Tecnologico de Monterrey, Mexico & Universidad Andres Bello, Chile); Santa Tejada and Blanca Ruiz (Tecnologico de Monterrey, Mexico)

The need to deepen understand the factors and actors that influence students' perceptions to pursue an academic and professional future in STEM areas has been study for over 30 years. In this study, we focus on students who are strongly oriented to science, technology, engineering and mathematics to investigate what motivates them, who has been cultivating that inclination. High school students who attended an international science contest on mathematics, physics, chemistry, biology and computing (over 600 participants in total) were invited to participate in a focus group. Thirteen students attended the call. The session lasted over 90 minutes and was video-recorded. The names of the participants are kept anonymous for this report. All the session was transcribed, and a group of researchers analyzed the data based on an adaptation of the expectancy-value theory. Results indicate that students do not feel they have the expected support from their schools, instead, their main support comes from their families (particularly their parents). It was interested to find that for this group of students, their conceptualization of STEM and their interest in how science and technology could be used to fulfill their aspiration (for a better world) came out to be a main factor to keep them pursuing their goals.

Track 8 - Full Papers VI

‡ Evaluation of a Snake Jaw Robot to Teach Integrated Biology, Mathematics, and Engineering

Lauren Garofalo, Samantha Sandler and Deeksha Seth (Villanova University, USA)

Due to the popularity of biomimicry, the integration of biology and applied sciences is becoming increasingly visible in curricula, especially in museums where animal-related behaviors are popular. Recognizing the need for interactive tools that can make the integrated education fun and effective, a biologically accurate model of a snake jaw was developed to teach an integrated lesson on biology, mathematics, and engineering. The goal of this work was to evaluate the effect of using the snake jaw robot on students' interest in engineering, biology, mathematics, perception of the robot's effectiveness, and ability to make connections between nature and engineering. Data was collected by administering a survey with 71 sophomore mechanical engineering students at Villanova University. The group of students was given a short lesson on the python jaw, focusing on the quadrate bone's function, followed by a demonstration. The group was split into two cohorts. The first cohort's demonstration used the robot while the second cohort's demonstration used an existing educational video. The survey was administered after the session. The results showed promise for both educational tools, the video, and the robot, compared to traditional lectures or problems commonly found in classes. The use of the robot showed significant benefit compared to the video when it came to students' interest in engineering and integration as well as students' ability to make connections between different disciplines. A complete understanding of the effectiveness of the robot can help (a) enhance educational programs by making them more integrated and hands-on, and (b) develop useful educational robots that can be used to instill an integrative mindset in students from a young age.

Lyapunov Based Trajectory Tracking Dynamic Control for a Qbot-2

Sabiha Wadoo (New York Institute of Technology, USA); Marc Vazquez and Mateusz Ardito-Proulx (NYIT, USA)

This paper presents the nonlinear control for a QBot2. Qbot2 is a differential drive wheeled mobile robot (WMR). In this paper we use both kinematic as well as dynamic models of the robot for the objective of trajectory tracking. The models are nonlinear and the control for trajectory tracking will be achieved using nonlinear control methodologies. The kinematic control is designed using a Lyapunov based nonlinear feedback control. The dynamic controller is developed using the method of backstepping. The paper presents the hardware implementation of both kinematic and dynamic controllers on the QBot2. The controllers are implemented on the system hardware using QUARC. QUARC is a MATLAB-Simulink based software where the results for tracking are obtained in real time. The controllers are implemented on the system hardware using QUARC. QUARC is a MATLAB-Simulink based software where the results for tracking are obtained in real time. for tracking are obtained in real time.

Evaluation of Smartphone-based Sound Level Meters

Trinity Cheng (River Hill High School, USA)

Free, widely-available smartphone-based sound level meters have been utilized to collect large quantities of distributed data in short time periods for the efficient creation of crowd-sourced noise maps. However, the accuracy of these apps can vary greatly as previous studies have shown. In this study, four smartphone-based sound level meters were tested to evaluate their agreement. Four experiments were conducted to test the impact of different apps, operating systems, smartphone hardware, and microphones on app measurements at different sound levels. A combination of four apps, four smartphones, two operating systems, and two microphone types were used in the tests, as well as a hardware-based sound level meter. Errors were evaluated based on two evaluation methods-root mean square error and linearity. The experiment results show that all of the apps produced different readings with respect to the same input stimulus. In other words, each of the apps, operating systems, smartphone hardware, and external microphones influenced the accuracy of smartphone-based sound level meters. Due to the wide variation in measurements, the usage of uncalibrated smartphone-based sound level meters seems to be unacceptable for serious noise assessments. However, the high linearity displayed by some apps indicates the potential for increased accuracy through calibration by professional-grade instruments.

STEM Outreach: A Literature Review and Definition

Ralph Tillinghast (US Army & CDC Armaments Center, Picatinny Arsenal, NJ, USA); Daniel C Appel (US Air Force Research Laboratory, Kirtland AFB, NM & Aegis Technologies Group Inc., USA); Carla Winsor (University of Wisconsin-Madison, USA); Mo Mansouri (Stevens Institute of Technology, USA)

Science, Technology, Engineering and Math (STEM) professionals are in demand to meet the current challenges within our society. STEM outreach plays a critical role in promoting, understanding and increasing interest in the STEM disciplines. Outreach activities provide a unique platform to reach students through many delivery methods and audience tailoring that bring impacts otherwise unattainable through standard curricula. This work presents a literature framework and review of works that pertain to STEM outreach. As part of the review, a stakeholder analysis has been conducted. Resulting in an understanding of stakeholder needs, goals,

and objectives, and analysis of STEM outreach efficacy for students from pre-K through post-graduate ages. From this review, a practical definition of STEM outreach is presented. The overall purpose of this work is to expand and aid in the further research to expand the benefits of outreach activities in the STEM fields to help prepare students for future STEM careers.

Student Performance Prediction from E-mail Assessments Using Tiny Neural Networks

Nikhil Yadav (St. John's University, USA); Kajal Srivastava (Jaipuria Institute of Management, India)

Predicting student performance using e-mail assessments can help in early interventions to better assist students sooner, rather than later, in STEM courses. In this paper, we propose CorC-Net, a tiny artificial neural network (ANN) that operates on limited data comprised of features scored from student assessments based on writing e-mails. ANNs are typically built using large scale data sets to truly realize their full potential; however, tiny neural networks overcome this problem by utilizing smaller batches of data making them easier to train. COrc-Net uses scored e-mails for content, organization, and clarity, and classifies how students will perform. Formative instructor feedback provided between the assessments implies that CorC-Net is a more logical fit to simulate the "learning" process when human reaction to feedback and corrective action is involved. This is true especially in sequential course assessment tasks. In this paper, we show that COrc-Net outperforms other multi-class classification algorithms like decision trees, support vector machines, Gaussian Naïve Bayes, and K-nearest neighbors. CorC-Net's success in classifying student performance shows great potential in courses where long-term temporal assessment data is not available.

Track 9 - Full Papers VII

‡ Middle School Students Learn Binary Counting Using Virtual Reality

Eric Nersesian, Margarita Vinnikov, Jessica Ross-Nersesian, Adam Spryszynski and Michael J Lee (New Jersey Institute of Technology, USA)

Educational fields that are abstract in nature, such as computer science (CS) and other science, technology, engineering, and mathematics (STEM) fields may find alternative teaching methods useful to maximize student opportunities to internalize and process the curriculum. In designing alternative CS educational tools in virtual reality (VR) technologies, the objective is to expose an academically diverse population to CS in an engaging and immersive environment. With this objective in mind, we built and tested a CS educational VR experience designed to teach students to count in a binary (base-2) number system. We found that by presenting the subject matter in a way that is gamified, engaging, and private, students were not only able to learn the concepts, but were comfortable in the process. Students were observed verbally walking themselves through binary counting tasks, expressing frustration when trying to solve a problem, and breaking out into victory dances when eventually solving that problem. Testing confirmed that the student group who learned how to count in a binary number system through this VR application were just as successful as those who learned from a certified CS instructor. This shows that VR educational experiences can be used as alternative teaching tools in CS education, which can supplement traditional teaching methods enabling new learning methods for students in the classroom and at home. We believe that this is evidence to support a larger effort in adapting the current CS education system to meet the needs of a more diverse student body that may find alternative teaching tools useful in internalizing abstract concepts.

Virtual Collaboration Training for Freshman Undergraduate STEM Students

Eric Nersesian, Jessica Ross-Nersesian, Adam Spryszynski and Michael J Lee (New Jersey Institute of Technology, USA)

Higher educational institutions formalize socialization for their incoming undergraduate student populations with traditional forms of physical classroom-based learning community (LC) skill-building environments; however, recent studies have shown that virtual LC environments can offer improved results over physical LC environments. This study examines whether incoming undergraduate STEM students gain the same benefits to their academic performance regardless of whether they receive LC training in physical or virtual reality (VR) treatment. We found that either treatment of collaboration training improve the participants' academic performance in comparison to the control treatment. In addition, we found that the VR participants gave more academic help in social settings to their peers throughout the semester than their control group counterparts. Upon interviewing the two treatment group participants, we found that virtualization of collaboration may impact perceptions on leadership roles, group functions, and thinking about the future. This research shows that virtualizing LCs has the potential to expand and supplement existing learning structures, and create new ones where they were not previously available, and aims to offer a better understanding of the strengths and limitations of introducing VR technologies in higher education.

Interdisciplinary Project Based Learning Approach for Machine Learning and Internet of Things

Muhammad Safeer Khan and Mohamed Ibrahim (Arkansas Tech University, USA); Nansong Wu (Sonoma State University, USA); Rajvardhan Patil (Arkansas Tech University, USA)

This paper reports on the use of interdisciplinary project based learning approach for undergraduate engineering education in machine/deep learning, and internet of things (IoT). Machine learning has evolved from pattern recognition and is an important element of artificial intelligence. IoT has also seen rapid growth in multiple application domains including embedded systems, wireless sensor networks, control systems, automation, and sensors. A challenge for traditional electrical/computer engineering curriculum is to effectively educate students in these areas without introducing specialized courses covering these subjects. There is a need to develop a project based learning approach to involve undergraduate students in real-world problem solving to develop use cases of machine learning and IoT. This paper reports on implementation of an interdisciplinary project based learning approach followed in undergraduate electrical/computer engineering curriculum. The students were involved in solving real-world problems through machine/deep learning. They also developed IoT applications in multiple domains to address limitations of existing systems and to go through the engineering design process. The qualitative results indicate that the PBL approach was highly effective in improving their learning outcomes.

A Hands-on Middle-School Robotics Software Program at MIT

Sabina Chen and Andrew Fishberg (Massachusetts Institute of Technology, USA); Eyassu Shimelis (MIT, USA); Joel Grimm (MIT Lincoln Laboratory, USA); Scott van Broekhoven (MIT, USA); Robert Shin (MIT Lincoln Laboratory, USA); Sertac Karaman (MIT, USA)

Robotics competitions at the high school level attract a large number of students across the world. However, there is little emphasis on leveraging robotics to get middle school students excited about pursuing STEM education. In this paper, we describe a new program that targets middle school students in a local, four-week

setting at the Massachusetts Institute of Technology (MIT). It aims to excite students by teaching the very basics of computer vision and robotics. The students program mini car-like robots, equipped with state-of-the-art computers, to navigate autonomously in a mock race track. We describe the hardware and software infrastructure that enables the program, the details of our curriculum, and the results of a short assessment. In addition, we describe four short programs, as well as a session where we teach high school teachers how to teach similar courses at their schools to their own students. The self-assessment indicates that the students feel more confident in programming and robotics after leaving the program, which we hope will enable them to pursue STEM education and robotics initiatives at school.

Instrumentation & Investigation of Phage-Antibiotic Synergy on *K. pneumoniae*, *H. alvei*, and Transductant *H. alvei*

Ibnat Meah (Dallatown Area High School, USA); David Singleton (York College of Pennsylvania, USA)

Antibiotics are powerful medicines that fight certain infections and can save lives when used properly. However, with bacteria becoming more resistant to antibiotics, new methods to treat bacterial infections are needed. One promising method for treating bacteria is the use of bacteriophages: viruses that infect and kill bacteria. This experiment investigated the effect of phage-antibiotic synergism on *Klebsiella pneumoniae*, *Hafnia alvei*, and transductant ampicillin-resistant *Hafnia alvei*. The trait for ampicillin resistance was transferred from *K. pneumoniae* to *H. alvei* using a device that was constructed in the lab. The zones of inhibition were then measured around the bacteria that were treated with the antibiotic discs alone and the bacteria that were treated with both the bacteriophage and the antibiotic discs. *Hafnia alvei*, *Klebsiella pneumoniae*, and the transductant ampicillin-resistant *Hafnia alvei* colonies exhibited larger zones of inhibition when the antibiotics were used in conjunction with the bacteriophages compared to when the antibiotics were used alone. The bacteriophages also made the transductant ampicillin-resistant *Hafnia alvei* colonies slightly susceptible to ampicillin again. This project demonstrates STEM integration into a high school biological science project.

Track 10 - Full Papers VIII

‡ *Electrical Engineering Core Course Laboratory Creation for Non-STEM Majors*

Christopher Martino, Dan Opila, Brent West, Louiza Sellami, John Stevens and Deborah Mechtel (United States Naval Academy, USA)

Practical laboratory exercises improve student understanding and motivation for learning abstract engineering concepts. The Department of Electrical and Computer Engineering at the United States Naval Academy (USNA), a four-year undergraduate institution, is tasked with teaching all students a course in electrical circuits and power. One version of the course is targeted for non-STEM majors. A part of this course involves a weekly two-hour laboratory period to assist in drawing out these abstract concepts. The instructors for the Electrical Engineering circuits and power course for non-STEM majors jointly developed and troubleshooted a series of five real-world, laboratory experiments. These experiments are intended to demonstrate real world skills and applications of the abstract concepts covered during the class. This paper describes the laboratory experiments and reviews the student feedback received on the educational value perceived by the students in these new experiments. The laboratory experiments were also ranked for educational value perceived by the students.

Active and Collaborative Learning Based Dynamic Instructional Approach in Teaching Introductory Computer Science Course with Python Programming

Mahmudur Rahman, Monir Sharker and Roshan Paudel (Morgan State University, USA)

In this era of smart devices, new technologies, gadgets, apps, and numerous systems and services available over online, teaching an introductory programming course by traditional lecture method faces challenges to draw student's attention; especially in their freshman year. In this work, we discuss our experience in teaching an introductory CS course by infusing both interactive and collaborative learning in pedagogy so that students can learn using interactive platforms, tools, technologies, systems, and services as available to them and collaboration within and among groups. For interactive learning, students used an interactive programming environment (e.g. repl.it classroom) as well as online eBooks. We designed several in-class exercises, assignments, small lab-based projects with example codes and expected outputs, and unit tests by using built-in unit tests library. We also, in the middle of semester, introduced collaborative learning through teamwork on well-defined projects during the learning time and submitted at the end. The collaborations include use of basic task management tools and multi-player tool of repl.it that the students can critic, supplement, improve peer works and learn. To evaluate the impact of this infusion, a pre- and post-survey were conducted on student cohort in two different semesters. The initial evaluation of the survey results and performances (final project and final grades) show evidence to conclude that the proposed pedagogical approach increased student motivation and engagement and facilitated learning to entry-level computer science students.

Student-Inspired Project-Based Learning in an Embedded Systems Course

Girma Tewolde (Kettering University, USA)

This paper presents the experience of the author from a senior embedded systems course at an engineering college. The course is primarily made up of lecture and laboratory components. Besides those two components the course also includes a peer-teaching component and a final-project. In the peer-teaching component the students are expected to choose a topic related to the course material, perform thorough research, and then present the material to teach it to the whole class. The goal of the final project component is to challenge the students to come up with a problem of their own that can be solved using the material learned in the course. The students are encouraged to dig deep into their creative minds and come up with practical projects that address real problems. They spend time to brainstorm ideas for their projects and present their proposals to the whole class for comments and approval, before they actually start to implement their work. The main take away from the experiences of these projects is that the students felt ownership of their projects and spent every effort to bring their ideas to fruition. Most of the project teams involved two or three students from different disciplines so they bring their expertise from their respective fields to the project. Overall, based on the grade performance of the students in the course and feedbacks received at the end of the course, this student-inspired project-based-learning approach was found to be successful in enhancing the learning experiences of the students.

STEM Outreach: A Stakeholder Analysis

Ralph Tillinghast (US Army & CCDC Armaments Center, Picatinny Arsenal, NJ, USA); Daniel C Appel (US Air Force Research Laboratory, Kirtland AFB, NM & Aegis Technologies Group Inc., USA); Carla Winsor (University of Wisconsin-Madison, USA); Mo Mansouri (Stevens Institute of Technology, USA)

The evolving challenges facing our society will increase demand for Science, Technology, Engineering and Math (STEM) professionals. Educational outreach in STEM areas can supplement current educational systems to promote interest, increase understanding, and encourage students to pursue careers involving STEM fields. In order to maximize benefits from STEM educational outreach opportunities, developing a better understanding of stakeholders involved, and their needs, goals, and objectives across the educational ecosystem is required. This work presents a stakeholder analysis for the STEM outreach system intended to enhance understanding of how each stakeholder in the STEM educational outreach system of systems contributes towards unique goals of improving student understanding and success in pursuing educational and career goals within STEM fields. Understanding the dependencies and relationships between stakeholder entities enables further research and future improvements for STEM outreach initiatives. Ultimately, these efforts aim to provide key contributions to building the next generation of science and engineering professionals.

Performance Improvement of 18-bit $\Sigma\Delta$ A/D Convertor

Aws Zuheer Yonis (University of Ninevah, Iraq); Khalid Mohammed (University of Mosul, Iraq)

The research paper presents a simulation study to develop and improve the overall performance of sigma delta ($\Sigma\Delta$) A/D modulator, the circuit structure and technique used were explained and the processes of different parameters of $\Sigma\Delta$ modulator over the conventional modulator were explained clearly. Simulated results of the proposed $\Sigma\Delta$ system shows a good improvement in the spurious noise produced by the conventional A/D converter. The advancement of technology made the modulators important component of any electronic system, generally the signal is analog in many applications such as telecommunications, video and computer system that depend on digital or binary signal in its operation, where it became necessary to convert the analog signal to a digital signal to take advantage of the power, flexibility and reliability of digital signal processing. The converters are complex because of consisting of many of the components of analog, such as Op-amps, sample and holds and comparative, therefore these modulators are very difficult to design, especially when they are implemented practically.

Outlook of Commonly used Biometrics and Assessment of Best Trait for High Level Security

Shahad Sultan and Mayada Faris Ghanim (University of Mosul, Iraq)

A biometric based authentication system is a security system that provides an automatic user authentication to access some areas, which require a certain level of security. Such a system is built based on some biometric traits possessed by the user. Although there are many authentic systems can be built based on different human biometrics such as face, fingerprints, iris, hand and finger geometry and voice etc. but all of these biometrics have their drawbacks and all of them can easily be forged. Human retina is a biometric trait that provides a secure and reliable source of person recognition as it is unique, universal, lies at the rare end of the eye and hence it is unforgeable. Therefore, among all other biometrics human retina can be used to build a

high-level security system. This paper makes an outlook on the commonly used biometric traits and states a comparison among them to prove that human retina is the best one for high level security areas.

Saturday, August 1 4:30 - 6:20

Poster Session 2

Development of stock correlation networks

Lixin Huang (Princeton International School of Mathematics and Science, USA)

How to depict the relationships between stocks has always been a focus for scholars. Knowing the relationship between two stocks means that we can adjust the investment plans based on the correlation between the stocks. We are able to lower the risk of the portfolio while maintaining its expected return if we know the correlations between the stocks in the portfolio, assuming that information carries on through time. In this study, we establish a method to depict the relationship between two stocks in a more generalized way, as to provide a new approach to find the relationship between two stocks other than correlation. The following four categories are taken into account: the correlation between the stocks, how close the stocks are in case of the category of the companies that issue the stocks, how frequently that the two stocks are mentioned together, and possible transaction in the business between the two companies that issue the stocks. To determine the relationships between stocks, an algorithm is initiated to generate a score between 0 and 1 for all four categories described above. Typically, a higher score indicates a more significant relationship between the two stocks. The data of the stocks are imported from the Wind database, including the price and category of the stocks. The business transactions between the companies have been taken from D&B Hoovers. Primary and secondary sources about the stocks will be considered as textual evidence. On the basis of the algorithm, the following 4-step analyses have been conducted. First, the correlation between the two stocks is calculated using the covariance matrix from the DCC-GARCH model. We assume the score of the correlation section equals the correlation between the two stocks. Second, if the fields of the two companies that issued the stocks are closer, the score for this section will be higher. Third, the score for the business transaction between the companies is determined by the proportion of transactions between the two companies. Last but not least, the score for textual evidence will be calculated using the equation below. $s_t = 1 - \frac{1}{\ln(n)}$ Where s_t is the score for textual evidence and n is the number of articles that mentioned both stocks. The final score between the two stocks is calculated by the weighted average of the scores for the four categories. After the score between each pair of stocks in the market is determined, an app is developed to display the top ten correlated stocks with the user's search to facilitate and optimize their selections in the stock exchange market. In the future, this research could be conducted in the following three aspects. To begin with, the weight for the score for each part can be adjusted with more stock examples in order to depict the relationship between two stocks more accurately. Furthermore, the graph can be more user-friendly to increase the engagement of the users. Last but not least, a more sophisticated, multi-level categorization can be developed to optimize the categorization of the stocks given.

Uncovering the Genetics behind Alzheimer's Disease and Sleep: A Co-expression and Evolutionary Analysis

Si-han Fei (Princeton International School of Mathematics and Science, USA); Ze-qing Li (Princeton International School of Math and Science, USA)

Alzheimer's disease is a fatal form of dementia, and it caused over 120 thousand deaths in the U.S. alone in 2017. Recent studies indicate that sleep deprivation is both a cause and an effect of Alzheimer's disease. Our research investigates the correlation between sleep deprivation and Alzheimer's disease through two stages. In the first stage of the research, the genetic coexpression of Alzheimer's disease-related genes (A-genes) and sleep-related genes (S-genes) across different stages of human development is explored. A general correlation between the expression of these two sets of genes is confirmed and strongly correlated A-gene and S-gene pairs are located, including GATA1 & ALAS2, TF & MOG, etc. In the second stage of the research, the expressions of A-genes and S-genes across different species are compared. Genes with unusual expression patterns in humans compared to those in other primate species are identified, hinting at possible genetic pathways key to solving the mystery of Alzheimer's disease.

Developing a Respiration Sensor for Babies

Ingrid J. Cruz (Oxon Hill Middle School & Southern University, USA); Michelle Soriano, Sarah Christie, Jazlynne Pichinte and Peter Chura-Borda (Oxon Hill Middle School, USA)

We designed and built a wearable technology that quickly and accurately measures the respiration rate of an infant. Specifically, a low-cost sensing device that can accurately measure the respiratory rate of a baby. An accurate respiration measurement is critical because an elevated Respiratory Rate is a marker of serious respiratory illness and is the main indicator for childhood pneumonia which is the leading cause of death in children aged 0 to 5 years worldwide. We started the project by researching existing sensors in the market. We first narrowed down the 2 main ways of measuring an infant's respiration rate. The first way is contact-based while the second way was non-contact based. We decided contact-based was the best option since non-contact ways were more difficult to try. From contact-based, we figured out that there were 4 ways of measuring the respiration rate. These 4 were the acoustic method, the Co2 method, the airflow method, and the chest and abdominal method. The acoustic method needed a microphone and we imagined it would be hard to get a microphone for a baby. The Co2 method was also expensive to afford. We couldn't find a device to go along the airflow method. The last option was chest and abdominal movement and we looked into it and it seemed like the best choice if we use a flex sensor with it. Coding took the most time on the project because we had to learn how to do it from scratch. Our code was based on previously published codes we found online that we combined together in order to make our respiration sensor work. The final prototype has the following design features: -We used an expandable waistband with velcro lock to make it adjustable and allow appropriate fit on different infants while at the same time ensuring comfort for the baby. We also made it double layered in order to hold the sensor in place and catch every movement of the chest. -We also added a little cut in the waistband to allow the flex sensor to be removable, making the waistband washable - We made a pink waistband and a blue waistband for if the parents wanted a certain color for their child. -We also made the code have a special feature in which if the baby stops breathing then the code will assume the baby is 'not breathing' and a buzzer on the device will sound. -To top all of that, we added an LCD screen to show the readings and the whole system connects to a battery making our design very portable.

Aerogel Composites: Historical and Novel Synthesis Methods and Applications

Michael Chen (Hillsborough High School, USA); Varun Deb (Hillsborough High School); Rohan Deb and Akindu Dasanayake (Hillsborough High School, USA)

Our poster seeks to provide a broad overview of the many wondrous properties of aerogel composites (which include hydrophobicity, low density, blue light scattering, and superb noise, heat, and electrical insulation), detail chronologically various methods of the material's synthesis (such as sol-gel polymerization and granular fusion), and offer insight into its vast array of present and future applications (in fields such as fashion, military, and construction). Research on our project began in May 2019 and is expected to be completed in March 2020. During the span of our research, we analyzed a wide selection of scientific papers detailing the fabrication processes, chemical and physical properties, and history of aerogel. To supplement our research, we performed live experiments (with the assistance of our AP Chemistry teacher, Mrs. Meyer) on a small monolith sample we purchased online. In one test, we placed the aerogel on a metal ring fixed to a stand above a Bunsen burner, lighted the burner, and then placed a match on top of the aerogel (the match remained unlit, demonstrating the material's extraordinary heat-insulating capability). Though our poster seeks, in part, to exhibit our experience in the classroom in research and experimental design in the field of materials science, it most importantly seeks to instill within the viewer a curiosity and awe for the highly promising future of this novel material.

Case Study of Asymmetries in Polar Rain Aurora

Dennis M Herschbach (Reservoir HS, USA); Yongliang Zhang (Johns Hopkins University Applied Physics Laboratory, USA)

Electrons and ions from the solar wind can directly enter Earth's polar upper atmosphere on both closed and open magnetic field lines. This occurs via the magnetosphere, where these particles are energized. When they then hit the neutral atmosphere, they ionize/excite molecules and atoms. Excited neutrals subsequently emit photons when they return to their previous ground state, which can have different wavelengths and are often visible to the naked eye such as in aurora Australis or aurora Borealis. Because they originate from the solar wind, auroral observations can reveal some of the physical processes that occur in the space that surrounds the Earth. A special kind of aurora, polar rain aurora (PRA), is a phenomenon caused by solar wind electrons that enter the polar atmosphere directly on open field lines. Precipitating electrons, which are not energized/accelerated by the magnetosphere, often have low energy flux and don't create visible aurora. However, satellite-based ultraviolet imagers have higher sensitivities and are able to detect lower energies. PRA events were obtained through a manual search of auroral images from the Global UltraViolet Imager (GUVI) on the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) satellite and the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) on the Defense Meteorological Satellite Program (DMSP) satellites. While PRA often appears in symmetrical and homogenous shapes, we present multiple events that exhibit unique spatial variations and structures such as shifts, tilts, or gaps. These features are likely due to structures in the solar wind energetic electrons, the magnitude and orientation of the interplanetary magnetic field (IMF), magnetic field reconnection, magnetic variations on the high latitude magnetopause, and/or a combination of the four processes above. In order to fully understand PRA variations and structures, a comprehensive statistical study as well as global magnetosphere simulation is required.

Nanoservice Infrastructure Notation (NINo) and the ASPIRE Interns

Chancellor T. Pascale (Johns Hopkins University & JHU APL, USA); Maria Rice (W. T. Woodson High School, USA); Shiva Sharma (Hammond High School, USA)

NINo is a future DevOps / Data Science pipeline tool that is being developed by JHU APL and two ASPIRE interns. The goal of this capability is to expose function-level capabilities, via either a simple application or configuration file, for use in Docker[1], Serverless Architectures[2], or data science/analytic pipelines. The goal is similar to efforts such as Metaparticle[3] and Source-to-Image[4] that aim to lower the barrier to horizontal scaling of data processing and analysis capabilities. In previous years ASPIRE interns have developed tools to ease the acceptance of DevOps principles in JHU APL. They have created a web application, Harmonia, that asked users a few simple questions and supplied the scaffolding for a software project with artifacts to support sound software engineering processes. The lack of user interest has driven us to a more focused objective. NINo will focus on easing deployment to cloud environments. Ideally, any person could develop cloud-based data science services. The team and its work has been organized in an asynchronous and agile manner. There have been three members working on three subsystems: configuration, framework/integration, and artifact generation. An incremental and prototype-driven approach has allowed for creation of increasingly more functional software as internship has proceeded. Interns have been given extensive control over their development processes and have investigated the programming frameworks used. While the initial stages have not resulted in a complete system, the interns have improved their programming skills and complete common coding challenges. The team is close to integration testing and initial demonstration. As the academic year closes, team members will work on design improvement, refactoring, and generation of future feature requests from prospective users. One summer intern will focus on developing a user interface for configuring and observing results.

Development of a System of Cerium(IV) Oxide Nanoparticles In Maximizing its Antioxidant Ability

Ziqi Jiao (Princeton Int'l School of Maths & Science, USA)

My research project incorporates the usage of Cerium(IV) Oxide nanostructures (nanoceria) to neutralize highly oxidative free radicals from an aqueous environment. The ultimate goal of this project is to modify and functionalize the nanoceria to maximize this antioxidant effect. The project is divided into 3 main stages: first, the nanoceria would be synthesized via hydrothermal methods, altering the reaction conditions each time to achieve controlled size and morphology of the nanoparticles. Secondly, the nanoparticles would have to be functionalized with smaller, biocompatible molecules such as ethylene glycol, poly vinyl alcohol, etc. Then, the antioxidant ability of the nanoceria would be tested quantitatively by mixing it with a free-radical generator and a dye that would discolor once oxidized by the free radicals (Photometric Evaluation). Future implements of the nanoceria would include testing its antioxidant ability in a in vitro environment and evaluating its cytotoxicity. Over the past 5 months, I have read countless online sources about the synthesis of Cerium(IV) Oxide nanoparticles and their biomedical applications. I gathered numerous methods of synthesis and conducted experiments for each of them. In total, I have acquired 4 samples of CeO₂ nanorods and 2 samples of CeO₂ nanospheres. These nanostructures have been sampled under a Transmission Electron Microscope (TEM) and produced representative images of their morphology and size. Furthermore, these nanoparticles have been confirmed of their CeO₂ content using FT-IR spectroscopy. One sample of CeO₂ nanorods has also been surface-modified using polyvinyl alcohol (PVA) and FT-IR results show that the polymer molecules are firmly attached to the nanoparticles and don't come off even after violent disturbing and washing using a high-

power sonicator probe. These results show that the synthesis methods viable in our laboratory turns out successful and with good yield. I have also discovered the complex method utilized by other researchers of coating the nanocerium on silicon dioxide nanoparticles, which should increase the number of active sites and make the nanoparticles more efficient. I have tried synthesizing a coating layer of SiO₂ on ferromagnetic nanoparticles to make the system easier to maintain, and further results are still pending. A number of photometric evaluations of the antioxidant ability of nanocerium have also been conducted. In brief, CeO₂ nanoparticles are mixed in an environment containing a hydroxyl radical source and a dye vulnerable to radical oxidation. The results show that CeO₂ nanoparticles have a significant effect in neutralizing part of the hydroxyl radicals generated, but the results are not as prominent as stated in previous research. Further tunes to the experimental conditions have also taken place, and results are still pending.

Effect of Roundup on Planarian Locomotion

Neelofar F Tamboli (Princeton International School of Mathematics and Science, USA)

Over time, the use of Roundup has been plummeting because of increasing glyphosate-resistant weeds. The main ingredient of Roundup is a toxic chemical called Glyphosate. Glyphosate inhibits a step in the Shikimic acid pathway. It prevents the plants from making proteins needed for plant growth, which has allowed it to become an efficient weed-killer. The purpose of this study is to investigate the effect of a widely used controversial herbicide called Roundup on flatworms called Planaria. The specific Planaria used in this experiment is called *Dugesia dorotocephala*. Planaria have an extraordinary ability to regenerate after they've been cut into two new individuals. They also have eyespots that act as photoreceptors and they tend to move away from light. The rationale behind using Planaria is that it is a good bioindicator since it occurs in the freshwater and testing effects on it will let us know about the effects on the entire ecosystem. Additionally, we should be very worried about the amount of Glyphosate contamination in our food supply since it has been on the rise. The experiment was conducted on the locomotion of Planaria and was evaluated by counting the number of 1mm by 1mm grid lines passed in a total of 2 minutes. The concentrations of Roundup that locomotion and regeneration were evaluated at were 0mg/L(control), 7mg/L, and 15mg/L. Our results indicate that Roundup inhibits locomotion in Planaria. There was no evidence found for a dose-dependent effect of Roundup on Planaria. Further research will assess alternative herbicides and pesticides to Roundup to see if they have any adverse effects on Planaria. Another future direction is on the exploration of neoblasts cells which allow the Planaria to regenerate. Finally, the future plan is to find an easy way to test the amount of Roundup in the environment.

Catalytic Ability of Ag-coated Ferromagnetic Microspheres Functionalized by TiO₂

Qiyang Zhou (PRISMS, USA)

TiO₂ has been used to clean wastewater as a photocatalyst that catalyzes the decomposition of organic pollutants through the production of reactive oxygen species. TiO₂ has previously been functionalized on Fe₃O₄ for improved recyclability of the nanoparticles, and Ag-coating is applied to enhance nanoparticle's catalytic ability by reducing the bandgap of the catalyst in other researches. In my research, I performed an experiment and will present a way of synthesizing Fe₃O₄@AgNPs@TiO₂ microspheres by functionalizing the ferromagnetic microspheres with silver nanoparticles before TiO₂. A photocatalytic test on the decomposition of methyl blue will also be performed to determine the catalytic ability of the obtained microspheres.

Quality Control of Brand Name Aspirin drug and Generic Aspirin drug

Jiale Lu (Princeton International School of Mathematics and Science, USA)

Brand name drug is developed and produced by the brand name drug company through a complicated process while generic drugs do not require complicated development and testing process. The huge price difference between the generic drugs and brand name drugs makes it important to analyze the differences in properties between these two kind of drugs. This research examines the physically and functional differences between brand name drug and generic drugs. The research primarily focus on the aspirin tablets sold on the market. The physical properties, such as width and weight, are measured. The uniformity of dosage unit is compared through the second derivative UV measurement to the aspirin inside the tablet. The function of the enteric coating is testified with solutions with different pH value in a dissolution tester. The disintegration rate for the tablets are measured and the total time for dissolving is also recorded. The final goal of this research is to find the difference and suggest one possible method for people to select between generic drugs and brand name drugs as well as one possible improvement for generic drug companies. From the result of the measurement, when comparing the aspirin pills from Bayer AG with generic aspirin, the consistency of the amount of aspirin in the brand name drug is greater and the coating is more effective when exposing to the acidic environment. The same method can be further applied to other drugs. Further studies can be done to improve the accuracy of this testing method.

Abstract of Kelvin Water Dropper

Edward Rossi Banfe (Princeton High School & Engineering Projects In Community Service, USA)

My poster is a demonstration of the Kelvin Water Dropper, invented by William Thomson in 1867. The goal of my project is to educate all those at IEEE about the basics of electrostatic induction through the Water Dropper, like William Thomson did. The poster will include a diagram of how the inductors and receivers work, will explain how a spark is generated from the flow of water, will display a working model of a Kelvin Water Dropper, and a laminated copy of the original paper by William Thomson for a demonstration. The Kelvin Water Dropper works via electrostatic induction, in which opposite charges accumulate in each side of the Dropper until a spark is formed, connecting the two sides for a brief moment and completing a circuit created by the built up positive and negative charges. After the spark occurs, the reaction restarts and the positive and negative charges begin to accumulate again. The charges are collected through the two hanging cans (inductors) and are stored in the cans diagonal to them (receivers). The receivers will pull water with an opposite charge to them and deposit it in the can directly below, causing more charge to be built up as the reaction continues and eventually stops to create a spark. My expertise regarding this project is adequate for what I will be presenting, as it is the project I have been learning and perfecting for last six months of my time at Princeton University's Engineering Projects In Community Service Joseph Henry Division (EPICS), led by Professor Michael Littman. In EPICS we specialize in projects relating to the history of electrical engineering, electromagnetism, and physics. We conduct outreach programs at local schools, libraries, and community events in the Central New Jersey area. In wit ion to my participation in EPICS, I am a student at Princeton High School in Princeton, New Jersey, currently at grade 10. I also volunteer for the Julia Robinson Math Festival which in Central New Jersey.

Magnet Dynamo - Princeton University EPICs

Hugo Kim (Princeton University EPICS, USA)

My poster is about the dynamo, a form of electric generator created by Michael Faraday in 1831. The poster will include diagrams and schematics of how the dynamo generates electricity, an early design of the dynamo, and a laminated copy of the original research published by Faraday for historical context. The poster's purpose is to demonstrate how early dynamos generated power, which aids in understanding their historical importance and applications. In short, the magnetic dynamo works by using rotating magnets to cut through the lines of flux created by magnetic wire (a "stator"). In other words, the dynamo generates electricity by rotating one magnet under the influence of a separate magnetic field. The moving magnetic field pushes electrons through the wire, which generates an electromotive force (a phenomenon described by Faraday's Law of Induction). As a result, electrons move through the wire, generating a current that can be used to power devices. Dynamos were the first electric generators powerful enough for industrial use; although the first dynamos used permanent magnets as the stator, the first industrial dynamo used electromagnetic coils as their stator. Passing a current through a conductive coil creates a much stronger electromagnetic field than permanent magnets. This happens because the magnetic flux lines produced all pass through the coil's center and overlap to create a very strong field. This principle allowed the dynamos using electromagnetic coils to produce enough power to be industrially viable. Today, most power stations have phased out larger dynamos for alternators. Alternators are also a type of electric generator, but unlike dynamos, alternators produce alternating current, which periodically switches direction. In contrast, dynamos only produce direct current (current that flows only in one direction). AC is now the way electricity is delivered to houses and businesses; this is because AC voltage is easier to control with a transformer, which makes the energy transfer more efficient. Nevertheless, the low-voltage DC current provided by dynamos is still often used in modern electronic devices, whose circuit boards only function with a unidirectional, constant current. I've been working on this project for over two months at a program offered at Princeton University by Professor Littman, known as Engineering Projects In Community Service (EPICS). The purpose of EPICs is to merge community service and engineering; we do this by creating projects relating to electromagnetism and presenting them at local schools and libraries during community events. Outside of EPICS, I'm a junior at Montgomery High School in Montgomery, New Jersey.

Demonstrating Lorentz Transformation Using Computer Simulation

Saniya Nagali (Allentown High School, USA); Anisha Iyer (Princeton High School, USA); Vanisha Nagali (Allentown High School)

Lorentz transformations are at the heart of Special Relativity as they are the correct description of how motion looks from moving perspectives in our universe. Lorentz transformations were developed to align with experimental observations which proved that speed of light is a constant in all frames of reference including moving ones. Spacetime diagrams - with distance as the horizontal axis and time as the vertical axis - are typically used to visualize how objects in relative motion perceive each other. To understand the perspective of the moving objective, we need to transform the spacetime diagram such that the relative velocity, represented as the angle between the curves of two objects in the spacetime diagram, stays the same. The easiest way to visualize are shear transformations where the "time" of the moving object is kept the same and the "distance" coordinate is moved to the right or left on the spacetime diagram. However, such shear transformations do not maintain the constant speed of light. Lorentz transformations were then derived to

obtain spacetime transformations that maintained the constant speed of light. For high school students studying physics Lorentz transformations can be non-intuitive and difficult to understand as they require the spacetime coordinate plane to slide, rotate and stretch in the correct proportions to maintain the constant speed of light. A simple visualization of different spacetime transformation approaches can be a helpful aid. We have developed a computer simulation that explains different transformation approaches (shear, Galilean, and Lorentz). We first modeled the coordinate plane using the AutoDesk Inventor software to develop a physical apparatus that mimics Lorentz transformations could be built. We then used a Java programming language to simulate the mathematical and movement concepts.

Best Predictors for Major Food Allergy Reactions Abstract

Will R Morrison (Princeton High School, USA)

Best Predictors for Major Allergic Reactions Abstract I have recently received a dataset with information about 680 Children's Hospital of Philadelphia food challenges and whether they had a severe reaction or a mild reaction. Food challenges are appointments where a child is given a food that he has been tested to have a small or nonexistent allergy for to see if they will react. If they don't, they are cleared of the allergy and can eat it outside of the controlled environment. In each of the 680 tests in this dataset the child reacted and data was recorded about the type of food, how much they ate, how they reacted to it, and how severe the reaction was based on a standardized scale. The goal with this data is to find out which of the 20+ columns is the best predictor for whether someone will have a severe reaction. For example, does a history of asthma make someone more likely to have a severe reaction? Or does sneezing during the test mean that they will have a severe reaction. So far, I have done a logistic regression with the data. Some findings have surfaced, but for the final project I would need to find what variables to drop and focus on analyzing the results. Below are some screenshots of the data and work that I have done with it: The first few entries in the dataset <https://i.imgur.com/TEl2ms3.png> A heatmap of the variables to determine which need to be dropped <https://i.imgur.com/qjZ1FLU.png>

Understanding Platonic Solids: Turning a Polygon into a 3 Dimensional Object

Sowmya Natarajan (Whittle School and Studios, USA)

My teachers had a difficult time teaching me how to find the surface area of a 3-D object, especially when I was looking at a 2-dimensional diagram. My goal is to teach people the concept of area and volume of a platonic solid through the use of 3-D pull up nets. A platonic solid is a regular, convex polyhedron. It is constructed by congruent, regular, polygonal faces with the same number of faces meeting at each vertex. Five solids meet these criteria: a tetrahedron, cube, octahedron, dodecahedron, or icosahedron. In 1994, mathematics educator Bob Vertes introduced E.B. Meenan to the idea of Pull-up polyhedron nets. These nets could be created using only a card and string and easily folded up into a beautiful, three-dimensional shape. Applications: Learning about volume and area through the use of platonic solids facilitates understanding and therefore easier for a person to apply these concepts in life. Using Pull-up nets is helpful to students who are visual or hands-on learners. Platonic solids are the basis for engineering, architecture, and geometry. Pull-nets can be used in many areas of life. Pull-up nets can form the basic design element of multiple objects from tents and bowls to prosthetic limbs. I want to advance the use of pull-up nets for tent-design, and as the basis for prosthetic limb design. One other interesting questions I will explore include: 1. Is there only one pull-up net for each Platonic solid. A good starting point to explore this question is to consider the eleven distinct nets

of a cube. I will explore if each of these formations form a string based Pull-up net. 2. What about other nets for other shapes like a tetrahedron (triangular pyramid)? 3. What about other polyhedra, do they have pull-up nets? My research based on the work of Bob Vertes, EB Meenan and BG Thomas makes understanding volume and surface area of a 3 dimensional object fun and easy. References [1] E.B. Meenan. "Be a Paper Mathemagician", from Motivate: Videoconferences for Schools [online]. [Accessed 15/01/2008.] Available from World Wide Web: [2] B.G. Thomas. Form, Shape and Space: An Exhibition of Tilings and Polyhedra. The University of Leeds International Textiles Archive, UK. 10 October 2007 - 16 May 2008. [3] P. D. Turney. "Unfolding the Tesseract", Journal of Recreational Mathematics 17, no.1, pp.1-16, 1984-85. [4] B.G. Thomas and M.A. Hann. "Patterned Polyhedra: Tiling the Platonic Solids" in R. Sarhangi and J. Barrallo (eds.) Bridges Donostia: Mathematical Connections in Art, Music, and Science, pp.195-202, 2007. [5] B.G. Thomas and M.A. Hann. Patterns in the Plane and Beyond: Symmetry in Two and Three Dimensions. Monograph no. 37 in the Ars Textrina series, The University of Leeds International Textiles Archive (ULITA). 2007. [6] Pull-up Patterned Polyhedra: Platonic Solids for the Classroom E.B. Meenan* and B.G. Thomas School of Education* and School of Design University of Leeds Leeds, LS2 9JT

What Effects Do Ultra Violet Rays Have on Yeast Colony Growth

Roshan S Natarajan (Whittle School and Studios, USA)

UV light triggers thymine to form thymine dimers inducing cell death. Though the sun provides heat and light, which are essential for life on Earth, ultraviolet (UV) rays in sunlight can cause damage to DNA. In this science fair project, I will experiment with a strain of yeast that is super-sensitive to UV light. The goal for this project is to find out what percent of yeast colony growth has been killed. Bakers yeast, or *saccharomyces cerevisiae*, is a eukaryotic unicellular organism. *Cerevisiae* is used in many laboratories as a model organism because it has internal organs such as a nucleus and a mitochondria. Since *cerevisiae*'s genes have been well-studied, researchers are able to separate genes of interest from others, called knockout genes. In this project, a knockout strain of yeast will be used. This modified yeast is designed to be DNA-repair deficient which means that this strain of yeast does not have the enzymes needed to repair damaged cells while regular yeast and human cells do. When UV light destroys DNA the light initiates a reaction with thymine creating a thymine dimer. If the thymine dimer does not repair properly there are two paths it can follow, become a cancer cell if the thymine dimers are not widespread, or die, if they are widespread. In this project, there are many thymine dimers that will be formed when the modified yeast is exposed to UV light causing the yeast to die. There will be two dishes next to each other with grown modified yeast. One dish will have aluminum foil on the top and the other one will not have aluminum foil. Then both of them will be exposed to UV light. This is the equation that is used to find out what percent of the yeast colony has died: $100 \times (1 - \frac{\text{colonies on exposed plate}}{\text{colonies on control plate}}) = \% \text{ killed}$ Two more tests will be done on the effects of pure UV light and the effects of regular light with no UV rays on yeast cells. This will show that the light is not effecting the yeast but the UV rays are. This project will demonstrate how DNA in yeast cells are damaged by UV light, causing yeast cells to die. Similarly, UV rays cause human cells to mutate by destroying DNA, which leads to skin cancer. Although modified yeast does not have the enzymes that unmodified baker's yeast and human cells have, it will still show how UV rays affect eukaryotic cells' DNA. A future application for this project would be using skin cells to see how they interact with UV rays and by doing this more research can be done on skin cancer. When I find out what percent of yeast died when exposed to UV lights I will compare it to the effects of skin cancer and see how the enzymes react differently to UV light and look at the difference between the modified yeast and the skin cell.

Homopolar Motor

Tvisha Bhanushali (Hillsborough Middle School, USA)

Good afternoon! My name is Tvisha Faria and I am currently an 8th grader studying at Hillsborough Middle School. I am part of Professor Littman's Engineering Projects in Community Service program at Princeton University. Using the vast concepts of science, we duplicate original experiments and share them via our events which occur in local schools, libraries as well as community programs. I have recreated a project known as the homopolar motor. My essential goal for this presentation is to teach individuals about the homopolar motor. I doubt many people know about the homopolar motor and I would like to inform people about their capabilities. Faraday's motor uses electromagnetism to create a rotational movement around a battery. Michael Faraday, the creator of the motor, was an English scientist of the 19th century, known for studying electromagnetism and electrochemistry. The homopolar motor essentially uses Lorentz force, a combination of electric and magnetic force, to spin a copper coiled wire around a battery and three magnets. This invention led to the making of motors and the discovery of electromagnetism in 1821. My poster board will include information about the history and the science behind homopolar motors. Students will also be able to learn about homopolar motors through innovation and interactive experiments. My group and I have done this project in the past and have presented it in front of other individuals. My presentation will include mini-experiments using the homopolar motor concept. Some of these experiments may include the battery and copper wire rotation or the circular battery motion on aluminum foil. My poster will include research about homopolar motors: their origin, evolution, fun facts, and more. My future goals are to continue to teach all about homopolar motors to people. My team and I often go to different locations to expose people to the realms of engineering and science. Homopolar motors fall under this category, and I am excited to teach individuals about how they work. Also, I have a younger sister at home who loves learning about circuits. In the future, I would like to show her this experiment, which could be incorporated in her life. Her elementary school hosts an annual science fair every year, which is when I can teach her this project in such a way that she can share it with her classmates. Essentially, my goal is to show people how homopolar motors work. I would like to show people how interesting science and engineering is. Thank you, Tvisha Faria tvishafaria@gmail.com

How STEM can help save lives in Tsunami prone areas

Joshua Tewolde (Grand Bland West Middle School, USA); Girma Tewolde (Kettering University, USA)

This poster is about how tsunami warning systems can be used in Tsunami prone regions. Tsunamis are devastating natural forces that are dominant in Southeast Asia, where there are a lot of developing countries that cannot recover quickly when a disaster strikes. With tsunamis come a lot of loss of life because tsunamis can be deadly. One of the best ways to prepare for a tsunami is to know in advance that a tsunami is coming. If you know that a tsunami is coming, you have time to leave the coastal area. Approximately 65% of Indonesians (about 171 million people) live within 50 miles of the coast. Moreover, coastal resources have been used for further economic growth in countries within that region. For example, these economic sectors account for 25% of the GDP and 20% of the workforce in Indonesia. Further income inequality in this region will drive more people away from their homes and towards the coastal areas where there is an influx of new jobs in manufacturing, fishing, and agriculture. This will mean that there will be more people in this area with high risk of tsunamis, intensifying the need for a reliable tsunami warning system that will keep the hundreds of millions of people in this situation safe. The tsunami warning system should be able to meet multiple criteria, including, but not limited to, keeping costs low, maximizing warning time, and minimizing false alarms

to avoid loss of public trust in the system. This system will have multiple parts, including the warning system and all the components that make it work. This poster makes an excellent example that ties into STEM in many ways. For the science portion, it relies on concepts of geology, such as how tsunamis are created, ways to detect tsunamis, and their impacts. We need to tie in technology in multiple parts of the system. First of all, we need to determine how to warn the public in the event of a tsunami, whether it be through mobile alerts/social media or possibly an alarm system throughout the region. We will also need to work out the technology needed to detect tsunamis, from the sensors to the control rooms. This includes learning the types and specialties of each sensor that could be used. Engineering will be a big part of this system, especially factoring into its design and deployment. We will need to use our knowledge of sensor types and tectonic plate boundaries in the area to make a prototype warning system. Mathematical equations and software simulation tools will be used to calculate the probability of a tsunami within a certain period of time and the effectiveness of the warning system. In conclusion, this poster demonstrates that knowledge in STEM is critical to help solve real world problems.

Defending Convolutional Neural Network-Based Object Detectors Against Adversarial Attacks

Victor Hu (Watchung Hills Regional High School, USA); Jeffrey Cheng (Bridgewater Raritan Regional High School, USA)

At the heart of many state-of-the-art image classification systems, including facial recognition systems and object detectors, is a convolutional neural network (CNN). A CNN uses thousands of pre-classified images to train a collection of numerical weights, which the network applies to each pixel of the input image in a series of layers to produce classification percentages. However, CNNs are by nature susceptible to adversarial examples. An adversarial example is an input image specifically generated to trick a CNN's collection of weights to incorrectly classify an image, although the image would look no different to a human observer. In safety-critical systems, such as autonomous vehicles, it is paramount that object detection is resistant to adversarial attacks. Autonomous vehicles rely on object detectors to identify things such as road signs and humans in their surroundings. We generated physically robust adversarial examples that successfully caused real-time state-of-the-art object detectors to misclassify road signs as other objects, a scenario where misclassification could result in damage and loss of life. In addition, we proposed defenses to mitigate misclassification. First, to prove that CNN-based object detectors are capable of reliably classifying stop signs under standard conditions, we tested the YOLOv3 object detector with normal stop signs as well as stop signs with sticker graffiti. A Raspberry PI car with a front-facing camera was used to simulate a passing car, reproducing dynamic perspective and lighting conditions. The car successfully detected a normal stop sign in 100% of the video frames and a stop sign with graffiti in 89.02% of the video frames across three trials. We then tested YOLOv3 with our adversarial attack designed to increase nonexistent "person" detection rates, which lowered "stop sign" detection rates to 58.74% and increased faulty "person" misdetection rates to 66.90%. To counteract the effects of the adversarial attack, we implemented defenses such as color thresholding and classification based on Haar features. The color thresholding snapped certain pixels to their closest associated color, thus perturbing the adversarial attack and allowing the CNN to successfully ignore the adversarial attack. Classification based on Haar features was a different method of classification that searched for certain features of a target classification. It acted as a safety net to our CNN, as the adversarial attack targets the CNN, but does not sufficiently perturb the Haar features. Implementing defenses such as color thresholding and classification based on Haar features returned "stop sign" detection rates back up to over 99%. Our work shows that adversarial attacks are substantial threats to the safety of autonomous vehicles by

tricking their object detection pipelines, but their effects can be mitigated by using a variety of defense methods.

Object Recognition Using TensorFlow

Nahuel E Albayrak (Chesapeake Science Point High School, USA)

Computers can apply vision technologies using cameras and artificial intelligence software to achieve image recognition and identify objects, places, and people. Deep learning algorithms set up basic parameters about the data and train the system to learn on its own by recognizing patterns using many layers of processing. Thanks to recent advances in small computers such as Raspberry Pi and Deep Learning algorithms, object detection applications have become much easier to develop. The objective of this project is to leverage these new technologies to detect an automobile as it drives by and estimate its location, travel direction, and speed. The procedure involved building an image capturing and classification system utilizing camera lenses and Raspberry Pi's small computers and using OpenCV as the image processing tool. In order to identify car features and predict a particular car's model and color, we used a machine learning framework called TensorFlow, and Google's pre-trained image model Res-Net-152 that was built from ImageNet dataset and Stanford car models data [1], [2], [3]. Finally, code was developed in Python to create a universal clock for each camera that recorded the detection time. As an automobile drove by, the camera system captured its image, recognized its model and color, and recorded this information together with the time and location on a log file. The information from the log was used to successfully identify a specific car's location and approximate speed. We performed trials using 4 different car models and obtained high confidence levels above 80% for most models. The lowest confidence levels belong mostly to sedan categories where models tend to look similar. Although our system was successful, it had a few limitations. Budget restrictions limited the number of cameras built to two. In addition, the information captured by the cameras was not transmitted in real time because WiFi or LTE capability were not available at the time. With a larger budget this system can be extended to include multiple cameras and real time data transmission. There are many applications for this system, offering significant benefits; from assisting law enforcement with vehicle identification in an emergency such as an Amber alert or detecting traffic infractions, to automating parking and drive-through systems. References [1] <http://www.image-net.org/> Imagenet data set [2] Stanfords Cars Dataset, (contains 16,185 images of 196 classes of cars) https://ai.stanford.edu/~jkrause/cars/car_dataset.html [3] Foam Liu, "Car Recognition with Deep Learning" Open Source; <https://github.com/foamliu/Car-Recognition> [4] OpenCV; Open computer vision; <https://opencv.org/about/>

Using properties of electromagnetism to construct speakers from paper cups

Anisha Iyer (Princeton High School, USA)

An electromagnet is a soft metal core that demonstrates magnetic properties after passing a current through a coil that surrounds. Modern speakers, which function as a result of interactions between electromagnets and permanent magnets, can be modeled using a paper cup, copper wire, neodymium magnets, a razor blade or sandpaper, an MP3 player, and some other related materials. First, the copper wire must be made into a coil of uniform radius. This is easiest when using a tool like a test tube. After coiling the wire, the coil must be unwound such that a few inches of free wire are available on either end of the coil. Next, the ends of the wire must be stripped, with a razor blade or sandpaper, until the copper-colored wire turns silver. Using the corresponding materials, the wire must be stripped to reveal silver-colored wire which can pass current from

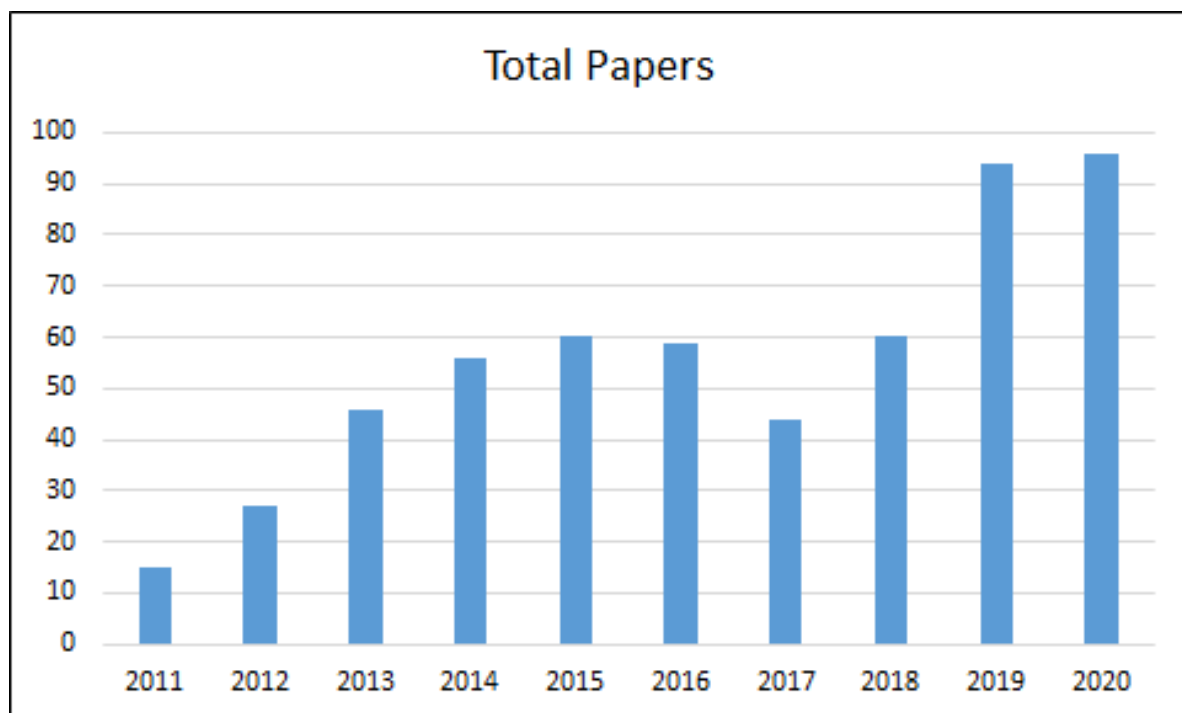
the MP3 player. To replicate the interaction between the electromagnet and permanent magnet, an electromagnet must be induced and paired with a permanent magnet such as the neodymium magnet. Audio connector cables should run from the headphone jack of the MP3 player to the terminal conductor. Two alligator clips, each from separate cables, should then be attached to the conductor, preferably by soldering. The other ends of each cable should be clipped onto the stripped ends of the coiled copper wire. These connections allow the electric current coming from the MP3 Player to pass back and forth through the coil. Passing a current through the copper coil creates an electromagnet by inducing a magnetic field, the direction of which depends on the direction of current flow. The copper coil should be secured to the bottom of the paper cup, preferably using a material such as double-sided tape or glue that does not interfere with the integrity of the coil. If this material dislodges some turns of copper wire from the copper coil, this will cause a muffled sound. For simplicity, the neodymium magnets can be placed on a cake pan. With the copper coil secured to the bottom of the paper cup, the paper cup can be placed onto the stacked neodymium magnets such that the coil hangs over the column of magnets. The magnetic field from the electromagnet will stretch over the neodymium magnets in a helical shape. Such arrangements allow the magnetic properties of a copper coil to interact with the north and south poles of permanent magnets, namely the ones attached to the cake pan. As current passes back and forth through the coil, it is alternately attracted and repelled from the magnets on the cake pan. The resulting force pushes the bottom paper cup back and forth, which in turn pushes the air back and forth to produce sound waves. The cone shape of the paper cup concentrates and amplifies these sound waves.

Levitating a graphite rod using the camelback effect

Anisha Iyer (Princeton High School, USA)

This project aims to investigate the relatively recently discovered "camelback effect" using my knowledge magnetic properties. In a system of two lines of transverse dipoles, the "camelback" field confinement effect can be recreated in a parallel dipole line system (PDL). The "camelback effect" occurs when two rows of magnetic dipoles are aligned to measure the strength of the field along the center axis. The magnetic field is stronger at the center and diminishes away from it. However, if the length of the dipole line exceeds critical length the field get stronger towards the edges of the dipoles and produces a confinement profile on the center axis that looks like a camel's back. This camelback effect can be produced using special cylindrical magnets with poles on the curved side. The effect can also effectively trap an object at the center of the axis along the positive y-axis. A graphite rod can work as the trapped object and will levitate perpetually without any input power as a result of the camelback effect. The graphite rod can also be levitated using a checkerboard of magnets, alternating according to their North and South poles.

2011 10 Years of IEEE ISEC 2020 2020



Paper per Year at IEEE ISEC			
Year	Papers	Year	Papers
2011	15	2016	59
2012	27	2017	44
2013	46	2018	60
2014	56	2019	94
2015	60	2020	96
TOTAL 557 Papers			

For Authors here are the stats for most frequent authors:

Authors:	# Papers	Authors:	# Papers
Top 10:		Notable Contributors:	
Abdullah Konak	12	Srijoy Dutta	4
Ralph C. Tillinghast	10	James Whitehair	4
Sadan Kulturel-Konak	9	Kara Vance	4
Edward A. Petersen	7	Vignesh Subbian	4
Amy Eguchi	7	Melvin Goodwin	4
Mo Mansouri	6	Natalia Mosina	4
A. Ravishankar Rao	6	Lisbeth Uribe	4
Eric P. Flynn	5	Briana Jewczyn	4
William Gray-Roncal	5		
Eric J. Page	5		

Top 5 cited papers:

52: Hamner, Emily, and Jennifer Cross. "Arts & Bots: Techniques for distributing a STEAM robotics program through K-12 classrooms." *2013 IEEE Integrated STEM Education Conference (ISEC)*. IEEE, 2013.

36: Karaman, Sertac, et al. "Project-based, collaborative, algorithmic robotics for high school students: Programming self-driving race cars at MIT." *2017 IEEE integrated STEM education conference (ISEC)*. IEEE, 2017.

34: Brown, LaVonda N., and Ayanna M. Howard. "The positive effects of verbal encouragement in mathematics education using a social robot." *2014 IEEE integrated STEM education conference*. IEEE, 2014.

31: Subbian, Vignesh. "Role of MOOCs in integrated STEM education: A learning perspective." *2013 IEEE Integrated STEM Education Conference (ISEC)*. IEEE, 2013.

31: Herger, Lorraine M., and Mercy Bodarky. "Engaging students with open source technologies and Arduino." *2015 IEEE Integrated STEM Education Conference*. IEEE, 2015.

Notable citation counts:

23: Sović, Ana, Tomislav Jaguš, and Damir Seršić. "How to teach basic university-level programming concepts to first graders?." *2014 IEEE Integrated STEM Education Conference*. IEEE, 2014.

20: Mercuri, Rebecca, and Kevin Meredith. "An educational venture into 3D Printing." *2014 IEEE Integrated STEM Education Conference*. IEEE, 2014.

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