ISEC 2021

11th IEEE Integrated STEM Education Conference

Virtual Online Conference
Princeton, New Jersey, USA
Saturday, March 13, 2021

Program Book

IEEE

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IEEE PCJS acknowledges Princeton University and SEAS for their continued support towards the previous IEEE STEM Conferences.

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 2021 IEEE Integrated STEM Education Conference

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CALENDAR of EVENTS – MARCH 13, 2021

9:00am – 9:15am - **Introduction**

9:15am – 10:00am - **Keynote Speaker 1 – Dr. Jayshree Seth**

"The state of science: On the global perception of science and the need for STEM Advocacy"
Dr. Jayshree Seth
Corporate Scientist
3M Applied Technology Lab

10:00am – 10:45am - **Keynote Speaker 2 – Prof. Dean Aslam**

"Creative Functionalized Bricks with Embedded Intelligence (FBEI) for Research-Oriented Provocative STEM and Workforce"
Prof. Dean Aslam
Director of BIOMEMS and Mind Laboratory
Michigan State University

10:45am – 11:30am - **Keynote Speaker 3 – Dr. Allison Jackson**

"STEM Pathways"
Dr. Allison Jackson
Managing Director and Member of the Board
Allison Jackson Associates (AJA)

11:30am – 11:30am - **Closing Remarks**

12:00pm – 6 Months - **K-12 Poster Presentations**

12:00pm – 6 Months - **Paper Presentations**

12:00pm - 6 Months - **Workshop Presentations**

KEYNOTE SPEAKER

DR. JAYSHREE SETH

"The state of science: On the global perception of science and the need for STEM Advocacy"

Jayshree Seth is a Corporate Scientist at 3M and holds 72 patents for a variety of innovations. She leads applied technology development projects for 3M's Industrial Adhesives and Tapes Division. She was appointed 3M's first ever Chief Science Advocate in 2018 and is using her scientific knowledge, technical expertise and professional experience to advocate for science. She has a PhD in Chemical Engineering from Clarkson University, NY and was recently awarded Society of Women Engineers (SWE) highest Achievement Award. She is also the author of "The Heart of Science - Engineering Footprints, Fingerprints, & Imprints", the proceeds of which go to a SWE Scholarship for Underrepresented Minority Women in STEM.

Dr. Jayshree Seth will provide an overview of the 3M State of Science Index, a global survey of more than 14,000 people in 14 countries to uncover what people think of science, and how they perceive its impact on their daily lives. Many of the survey findings highlight the importance of reducing real and perceived barriers to science appreciation and STEM education, not only to ensure that we have a healthy pipeline of future scientists and engineers to solve the complex and global humanitarian challenges we face, but also for society to accept the solutions. She will also provide her reflections on the results so far and perspective on the path forward.

KEYNOTE SPEAKER

PROF. DEAN ASLAM

"Creative Functionalized Bricks with Embedded Intelligence (FBEI) for Research-Oriented Provocative STEM and Workforce"

After his Ph.D. (Dr. rer. nat.) in EE in 1983 from Aachen Technical University (RWTH), Germany, Dr. Aslam was Assistant Prof. of ECE at Wayne State U, Detroit, MI for 2 years. He joined Michigan State U in1988. Dr. Aslam did seminal research in scientific mind model, cap-mounted mind-controlled LEGO robot, passive maple-seed robotic fliers, single-material MEMS, energy scavenging from static charges, FBEI modules for research-oriented STEM education, all-diamond MEMS neural probe, highest quality factor of 116,000 for microcrystalline diamond (MCD) resonators, all-diamond MEMS packaging, field emission electroluminescence (FEEL) in MCD, highest intra-grain piezoresistive gauge factor of 4000 in MCD, high temperature superconducting films on Si substrates, and common origin for electron and hole traps in MOS devices. Dr. Aslam was awarded 10 patents and approx. $ 5 million research funding in the past 20 years. His current research focusses on (a) self-study of neural problems using mind-controlled LEGO robots, (b) empathy-controlled robot to study narcissism, sociopathy and psychopathy, (c) cancer-avoiding herbal diet, and (d) personality prediction using EEG and facial data

Abstract: Creative Functionalized Bricks with Embedded Intelligence (FBEI), using custom-made LEGO-compatible bricks containing electronic circuits & sensors based on new micro & nano technologies, spark the interest of learners with different backgrounds and preparation levels from kindergarten to Ph.D. FBEI modules are based on a concept called TASEM (technology assisted science, engineering and mathematics) supported by NSF Engineering Research Center for Wireless Integrated Micro Systems (WIMS) during 2000-2010 under Award Number EEC-9986866. Doctoral students, involved in innovative micro and nano research, interacted with K-12 students and teachers to develop TASEM. TASEM led to unique FBEIs covering many learning areas including energy, power sources, math, Si crystals, computer switches, sensors and miniaturization, micro and nano concepts, technology assisted dancing, psychology, cognitive training, cancer education, microsystem fabrication, system integration, biomedical, and computer science. By allowing user-designs, FBEIs focus on research-oriented and entrepreneurial learning. Over 100 FBEI learning modules were developed benefiting over 2,500 learners nationally and globally. Most of these STEM modules are unique in the world.

KEYNOTE SPEAKER

DR. ALLISON FRAZIER JACKSON

"Future Work: EE STEM / CTE Resources"

Dr. Allison Frazier Jackson operates a private consulting firm, Allison Jackson Associates (AJA), which she founded in 1982. Allison serves as both Managing Director and Member of the Board. She has worked with more than 23 CEOs of Fortune 500 companies, offering workforce development and change management across manufacturing, consumer electronics, IT services, network television, bio-pharmaceutical, telecom, environmental, primary care, and professional services. She was the first woman and African American assistant dean at Princeton University School of Engineering and Applied Science. She founded the National Engineers Week event program at Princeton, grew the E-Quad Newsletter from 1200 circulation to 30,000 in 1.5 years and served as liaison to 13 industry panels and 6 student societies in engineering and materials science. Over the past 15 years she has established herself as a thought leader in STEAM programs for kindergarten to graduate school programs. She was the author the Hearts, Hands and Minds Framework, winner of STEM Ecosystem grant bringing services across 8 counties in South Jersey. Founder of the Million Women Mentors, NJ Chapter, and winner of the national prize for its program development; and currently a State Judge engaged in STEAM TANK competitions for K-12 students moving STEAM projects to entrepreneurial pursuits that fund youth businesses or patent products. Her current work includes attracting homeless youth and their families to STEM programs. Allison holds five degrees: B.A., New Jersey City University, M. ED, M.C.R.P., Rutgers University and M.S. Project Management, Stevens Institute of Technology, and ED. D, and has completed all courses for PhD in Urban Planning from Rutgers University.

Future Work: Engineering. It is important for engineers, scientists, educators, public health officials, students, and community outreach professionals to understand the impact of change using clear frameworks that create solutions and prepare for skills needed in the future workforce. This talk focuses on examples of four areas of change: people, process, organization, and technology. It provides links to STEM / CTE resources that support the growth of competencies in each area change to help people crosswalk to new careers.

The work is supported by data collected between 2019 -2021 and focuses on skill crosswalks that help the individual's pursuit of careers in engineering. Our speaker, Dr. Allison Frazier Jackson will share her experiences serving academic, corporate, government, and R&D organizations. She will also address her new healthcare engagements which require collaborative connections between medical, social services, education, government, and engineering personnel.

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, Adro!t. 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.

2021 Best Paper Award Nominees

2020 Best Paper Award Winner

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)

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Saturday, March 13, 2021		IEEE ISEC2021			
9:00am	9:15am	INTRODUCTION			
9:15am	10:00am	Keynote Speaker 1 - Dr. Jayshree Seth			
10:00am	10:45am	Keynote Speaker 2 - Prof. Dean Aslam			
10:45am	11:30am	Keynote Speaker 3 - Dr. Allison Jackson			
11:30am	12:30pm	K-12 Poster Presentation - Morning Session			
11:30am	12:30pm	Full Papers - Midmorning Session			
		Works-In-Progress I	Track 2 - Full Paper I	Track 3 - Full Paper II	Track 4 - Full Paper III
12:30pm	1:30pm	Work Shops			
1:30pm	3:00pm	Full Papers - Afternoon Session			
		Works-In-Progress II	Track 5 - Full Paper IV	Track 6 - Full Paper V	Track 6 - Full Paper VI
1:30pm	3:00pm	K-12 Poster Presentation - Afternoon Session			
3:00pm	4:45pm	Full Papers - Evening Session			
		Works-In-Progress III			
3:00pm	4:45pm	K-12 Poster Presentation - Evening Session			
4:45pm	5:00pm	Closing Remark			

Saturday; March 13, 2021 11:30 - 12:30

K-12 Poster Presentation - Morning Session

Poster Session 1

Novel application to improve communication for children affected by Autism Spectrum Disorder

Veda R Murthy (Rachel Carson School, USA)

Autism Spectrum Disorder (ASD) is a spectrum of disorders that affects a child's communication, social, and emotional skills. ASD is a major challenge for children because they are not able to communicate effectively with others, especially in terms of conveying their emotions. For the 40% of ASD children who are mute and are not able to verbalize their emotions, facial expressions are the primary indicator that family members and caregivers use to recognize their emotion. ASD children display facial features unique to each child, so those who are unfamiliar with the child such as teachers may find it difficult to interpret the child's emotions. This creates a communication barrier between ASD children and the outside world, leading to frustration and isolation among the 13.7 million ASD children around the world.

Current solutions to help ASD children socialize, such as speech practising or assisted learning apps, do not reduce this barrier. This is because these apps are not an immediate solution to this barrier, and can be effective only after months of practice by the child. Also, most of these solutions do not work for mute ASD children. Thus, there is a dire need for an individualized solution that interprets an ASD child's emotion.

My solution is the Cognitive Emotion Interpretation App (CEIA). CEIA uses Artificial Intelligence and Emotion Recognition Technology to map an ASD child's facial expressions with an emotion. Through CEIA, people who are not familiar with the ASD child (teachers, extended family) can interpret the child's emotion. When a user (parent, caregiver) downloads the app, they upload photos of the ASD child expressing different emotions and tag the picture with the emotion (e.g. Happy, Sad, Frustrated, Hungry). CEIA then extracts the child's facial features, and the AI algorithm is trained to associate the picture with the emotion. When the user wants to interpret the child's emotion, they take a photo of the child exhibiting the emotion and upload it to CEIA. The AI algorithm will evaluate the photo, and list the emotions that match with the highest accuracy. The user can also upload more photos at a later stage, and the AI algorithm will be retrained to take these new photos into its training dataset. A higher number of photos used in training generally yields a higher recognition accuracy, thus users are encouraged to upload many photos of the child's emotions.

The performance of the app will be evaluated on the following metrics: 1) accuracy of the emotion recognizer, 2) amount of time CEIA takes to recognize the emotion, and 3) CEIA's ease of use. Accuracy will be measured by collecting a sample of a variety of emotions of different users, then measuring if CEIA correctly matched the emotion in the photo. This initial test of accuracy will provide a representative sample of the types of emotions CEIA will need to train on. CEIA will provide a much needed powerful tool to reduce the communication barrier between ASD children and their community.

An Autonomous Driving Simulation Platform as a Virtual HSAVC Competition Environment

Daren Hua (Eleanor Roosevelt High School, USA)

At ISEC 2018, Professor Marc E. Herniter presented the High School Autonomous Vehicle Competition (HSAVC), which introduces autonomous driving to high school students. The competition promotes STEM education by challenging participants to use MATLAB to create a vision-based track detection algorithm and Simulink to build a motor controller model. Following the COVID-19 global pandemic, many in-person STEM competitions were cancelled, including HSAVC. The goal of the Autonomous Driving Simulation Platform is to provide a virtual alternative to the in-person competition to adapt the opportunity of the HSAVC for an increasingly digital world. Using MATLAB, the Simulation Platform creates a real-time virtual environment for students to test their HSAVC track detection algorithms and motor controller models. The Simulation Platform consists of two MATLAB apps: a Track Generator and a Driving Simulator. The Track Generator application can create fixed tracks based on user inputs or randomized tracks based on user-defined lengths. The Track Generator utilizes a growth and mutation algorithm to create a track with three distinct track sections: straight, left curve, and right curve. The Track Generator's randomized track replicates the HSAVC's physical track, and the Driving Simulator replicates the HSAVC's 1:18 scale autonomous vehicle equipped with a linescan camera, a microcontroller, two drive

motors, and a servo motor with three functional components: a vehicle model, a track model, and a camera model. The user interface includes fields to specify the input file paths and options to configure the physical parameters of the vehicle and camera. In addition, a Track View displays the vehicle's real-time position and orientation on the track while a Camera View captures real-time camera signals. Two proof of concept MATLAB apps (Track Generator and a Driving Simulator) have been successfully designed and packaged in MATLAB App Designer. Users can create a track and test their algorithms and models through an intuitive interface, making it an effective tool for STEM education in any classroom. The Autonomous Driving Simulation Platform holds potential as a solution to the HSAVC competition during the pandemic and can increase student engagement in the HSAVC from high schools around the world. The successful virtual adaptation of HSAVC demonstrates how simulations can be used as a critical tool for in-person STEM competitions to continue in digital form.

Desalination and Purification of Water using a Solar Powered Hydrogel Multistage

Kevin A Murphy (PRISMS, USA)

The United Nations has a goal to supply clean water and sanitation for all. This goal sprouts from the fact that one in three people do not have access to clean drinking water. Clean water is an essential resource for our survival, yet we waste and pollute it. 2.5% of the Earth's water is fresh yet only .5% is drinkable. As well as this, our already meager water resources are being threatened by climate change as weather patterns change and sea levels rise. An example of this is San Diego's water supply which comes directly from the Colorado River but, due to a change in weather patterns, the Colorado river level is falling forcing San Diego to look elsewhere for clean water (2). Another example is Melbourne's, and many other Australian cities', water supply that took a heavy hit during the Millennium Drought.

To fix problems like this desalination plants are being built. However, the processing of water in these plants is expensive ranging from 1,000 to 2,000 US dollars per acre-foot (of water), 10's to 100's of millions per year in maintenance (3) and billions to build the plants in the first place. The construction of these plants also require infrastructure that developing countries, countries that need clean water the most, simply do not have. The current and mainly used methods of desalination are reverse osmosis and thermal evaporation (2). Thermal desalination isn't commercially viable due to its intensive energy requirement so reverse osmosis plants have become the favored design. However, these plants have many consequences such as toxic waste pollution and killing of local wildlife (2). This industry is crucial to humanity's survival, yet it has so much room for improvement.

Despite humanity's access to a large supply of salt water and polluted fresh water, we are without an efficient and versatile means of making it safe to drink. This study aims to change that. This study aims to design, build and test an easy to use, highly efficient, solar powered and portable water purification method that can be used across the globe. This design will produce water via highly efficient evaporation which will cleanse it of contaminants, including microplastics. In this study a water vaporization enthalpy decreasing chitosan and PVA hydrogel was synthesized and freeze dried repeatedly at -80C to stimulate the expansion of pores within the hydrogel. Additionally, a multistage of these hydrogels was designed and is undergoing construction and testing in tandem with a solar tracking nested paraboloidal solar concentrator. It is hypothesized that this design will have a purification rate of ~10L per hour. The testing of the purification rate will depend on the quality of the prototype and the prototype's heat capacity. This design will also undergo field trials that will test its ease of use and its resistance to damage. The results of this study will determine the feasibility of this design in the real world and whether it can realistically be of benefit to those without clean water.

Comparing Grover's Quantum Search Algorithm with Classical Algorithm on Solving Satisfiability Problem

Runqian Wang (Princeton International School of Math and Science, USA)

The emergence of quantum computing provides us the possibility of solving tasks that might take years classically in just a few minutes. For certain problems, quantum computing exhibits quantum supremacy, meaning that the quantum solution runs exponentially faster than classical algorithms and is able to completely take over classical computers. This high efficiency of quantum computing comes not only from the hardware but also the software, quantum algorithms. The algorithms utilize the qubits to make calculations in order to fulfill specific tasks with the lowest time complexity possible. One such algorithm is named the Grover's algorithm, which is able to perform database search in O(sqrt(N)), and it runs much faster than the traditional algorithm that takes O(N) time to solve the same task. For example, when the task is to find the even integers from N integers, traditional computation will need to run through all of the N integers one by one, making at least N steps of calculation, while by using Grover's algorithm only around sqrt(N) calculations are needed. This exponential speed-up makes Grover's algorithm one of the most important quantum algorithms. Grover's algorithm has a wide application in many fields and is able to improve the time complexity exponentially. One task that can be solved

using Grover's algorithm is the satisfiability problem. This type of problem asks the computer to find a set of values (commonly true or false) for several variables such that they satisfy certain constraints. We use k-SAT problems to refer to satisfiability problems with k boolean variables to be determined. Grover's algorithm can effectively solve the k-SAT problem by performing the database search on 2^N possible states of the variables. The algorithm's square root optimization on searching helps to improve the efficiency of this solution significantly. Furthermore, this optimization of Grover's algorithm may play a more important role when k grows larger, and consequently the efficiency of the quantum solution could improve faster relative to the traditional solution. Yet this hypothesis is never tested due to the lack of a general k-SAT quantum algorithm. No quantum algorithms solving k-SAT problems where k is greater than 3 have been proposed, thus no test has been performed to compare the quantum solution and the classical solution on more general k-SAT problems. In this research, we formulate a general quantum solution for k-SAT problem and compare such solution with the best classical algorithm to determine whether and when the quantum algorithm performs better on satisfiability problems. The comparison will be done through both theoretical deduction as well as real-world implementation. At the end of this research, we will determine whether the proposed quantum algorithm outperforms the classical algorithm on solving k-satisfiability problems.

Making a mechanical hand with plastic drinking straws.

Sowmya Natarajan (Whittle School and Studios, USA)

Hi my name is Sowmya Natarajan and I will be presenting a mechanical hand made from plastic drinking straws. The purpose of this project is to be able to pick up objects using the fingers. I will have 5 strings controlling 5 different fingers. The fingers will be able to pick up objects such as water bottles and paper crushed into a ball. I got this idea from my mentor who suggested it, and she was also telling me how it corresponds to prosthetic arms. I was inspired by the fact that I could replicate something so high tech from everyday materials like plastic straws and string. However, while working on this project I came across many challenges. This led me to think about these questions. If you cut the holes the same size will the hand still work? If you cut the holes larger will the hand still move all the joints? If you cut the holes closer/farther together will it function better? After multiple tries I realized there was a formula to making the hand, and the formula answered all my questions. The first hole needs to be the largest hole the middle hole needs to be medium sized and the lowest hole needs to be the smallest hole. After knowing this I successfully made the hand.

Predictive Analytics in Agriculture using Geospatial Mapping

Sreya Jonnalagadda (Princeton International School of Mathematics and Science, USA)

Smart farming has become increasingly popular over the past years and has been making great contributions to the agricultural industry. Techniques such as precision farming, predictive analytics, and geospatial visualization are being used in agriculture to help with efficiency, profitability, and optimization. In my research project, I plan on applying predictive analytics on local (New Jersey) farm data to discover and analyze future trends and patterns. Then, using geospatial mapping (utilizing the ArcGIS platform), the findings drawn from the data will be illustrated to provide clarity. These conclusions can be used to provide future direction and make further advancements. For example, an app(that displays the analytics and findings) can be created and translated to the farmers to help provide suggestions and allow them to understand their farms better. In addition, the findings could lead to a further study involving specific crops or technologies.

Household 3D Cream Printer for Cake Decoration

Junjing Zeng (Branksome Hall, Canada); Fangzhou Xia (Massachusetts Institute of Technology, USA)

Making beautifully decorated cakes at home can be a great joy for baking hobbyist especially during the time of social distancing. However, creating beautiful patterns on the cake is a labor-intensive task that requires a significant amount of skills. For novice bakers to create amazing custom cake decoration, 3D printers can be an invaluable tool. Since its invention in the 1980s, 3D printing technology has evolved significantly to enable various new fabrication capabilities. In the last decade, the food industry has also started to adopt this technology for printing chocolates, candies, dough, or meat. 3D printing has amazing flexibility to realize customized designs with complex geometry, which makes it ideal for cake decoration. Moreover, 3D printers have become widely available as affordable consumer electronics. Therefore, to reduce human labor and skill requirements, we intend to repurpose a 3D printer for cake decoration, which has not been realized before.

In this poster, we present the design of a Cream 3D Printer for cake decoration at home. The system is designed to create the desired geometry with cream, produce multiple materials/colors and be affordable (hundreds of dollars). For the

initial investigation, the prototype design is modified from a Fused Deposition Modeling (FDM) 3D printer. The four primary subsystems include a 3-axis motion system, a material extruder, control algorithms, and an environment control chamber. For the 3-axis motion system, a Creality Ender 3 Pro 3D printer is selected as the basic structure since it is affordable, open-source, and well-supported by its community. The plastic material extruder is replaced by a custom-designed cream extruder. Whipped cream is placed in multiple syringes pushed by the slider on lead screws actuated by stepper motors. Plastic tubes are used to guide the cream from the syringes to the nozzle for ejection. Multiple nozzles or a single nozzle with multi-way valves can be used to select materials from the syringes. For the control system, G-code generated by the slicer from a Solidworks 3D design can be directly used for single material printing. To select between multiple materials, a custom Python program processes the G-code and uses serial communication to interface with the 3D printer Marlin firmware and an Arduino microcontroller. The environmental control chamber helps to cool the printed cream and improve its rigidity so that complex 3D shapes can be printed. The temperature control can be realized with simple commercial refrigeration systems.

At the current stage, the single nozzle cream extrusion capability is completed for the cream 3D printer. Coordinated control of the Ender 3 Pro 3-axis motion system and the custom nozzle has been realized for cream printing. We are currently investigating the effects of temperature and other printing parameters for various potential cream mixtures to identify the configurations suitable for printing. The multi-material printing capability will be developed after identifying suitable materials. With the 3D cream printer, we hope to empower novice baking hobbyist to create amazing cake decoration without years of practice.

Low-cost Portable Ventilator Design for Underdeveloped Regions

Rui Wang (High School Affiliated to Renmin University of China); Fangzhou Xia (Massachusetts Institute of Technology, USA)

The coronavirus disease (COVID-19) pandemic has significantly challenged the world in many ways especially for the medical sector. One of the most important challenge is the shortage of ventilators for COVID-19 treatment. In 2020, nearly one hundred million people have been infected globally, where at least ten percent of the patients may develop severe respiratory distress that require ventilators for treatment. Since conventional ventilators are high-end medical equipment not commonly used, the stock numbers are insufficient as cases surge. For example, around 2000 people share one ventilator in the U.S at the beginning of the pandemic. Such a shortage is even severer in underdeveloped countries such as the Central African Republic where millions of people need to share a single ventilator. On the other hand, ventilators are vital to increase the survival rate of patients in critical conditions. As the coronavirus damages lung function and impedes oxygen absorption, ventilators assist breathing by pressurizing air into lungs to maintain the blood oxygen concentration. Existing ventilators are not designed for handling the pandemic especially in third-world countries. High-end ventilators typically cost more than $10k per installment and cannot be easily produced. On the lower-end, Bag Valve Mask (BVM) requires manual pumping that yields high risk of infection. Researchers at MIT has developed automated BVM-based ventilator. However, the important functionalities for patient biometric sensing and doctor alarming are still missing from previous designs.

In this poster, we present our solution to this challenge by developing a low-cost portable ventilator with three main highlights. First, with $300 target budget, the system can be produced in large quantities for use at temporary mobile cabin hospitals. Second, a patient monitoring system for blood oxygen and electrocardiogram are included with wireless alarms to notify doctors in case of emergency. Third, the exhaled air will be disinfected by specialized filter to reduce the risk of cross infection. The oxygen supply mechanical subsystem design is centered around a BVM compressed using a mechanism driven by a stepper motor. Supplemental oxygen can also be added from portable canisters. The electrical subsystems are primarily based on the Arduino microcontroller platform for both oxygen supply control and sensor signal processing. A custom instrumentation-amplifier-based electrocardiogram circuit and an infrared oximeter sensor are designed to measure patient biometrics. A wireless communication scheme is realized with Bluetooth modules for remote monitoring and can operate as an alarm to the doctor. The assembled prototype is currently capable of supplying oxygen to normal adults with a lung capacity of 6000 ml. It can also conduct simple measurement of heart rate and blood oxygen concentration with remote monitoring. The on-going tasks involve selecting exhaled gas disinfecting filter and processing signals to identify abnormal biometrics. Additional work on improving the portability of the design with battery operation is also planned. We hope this affordable open-source design can help underdeveloped countries overcome the current challenges and be better prepared for future pandemic crisis.

Water purification for human consumption

Sumanth R Moole (Thomas Jefferson High School for Science and Technology, USA)

Project Objectives:

This project is to research, propose, and test the alternatives to the current water purification methods. Two most important objectives are to reduce the cost and make the solution available to the people with minimal infrastructure.

Problem Description:

Water is critical for life. Even though two thirds of the earth surface is covered with water, not all of it is suitable for human consumption. United Nations statistics show that 1.2 billion people, or almost one in every five, have water scarcity now and another 1.6 billion people do not have sufficient infrastructure to use the water available to them in rivers and aquifers (https://www.un.org/waterforlifedecade/scarcity.shtml).

Water extracted from rivers, lakes, and aquifers is not suitable for human consumption in most cases without purification. Water purification is expensive and difficult process which requires chemicals like Aluminum Sulfate. These chemicals interact with suspended solid particles in the water in a process called flocculation, which creates heavy particles that sink to the bottom. After flocculation, the clear water is further purified with Chlorine or other anti-microbial chemicals. These chemicals are produced in expensive factories and require transportation over long distances to reach the intended population. The infrastructure required to collect, purify, and distribute the water is very expensive and requires large capital investment for long term. These high costs and requirement of capital investments are further complicated in politically unstable regions of the world. In view of this background, there is a need to find innovative solutions to the water purification to reduce costs, capital investment, and bring the solutions to the needy people.

Research, proposed solution, and results:

This research was focused on how different civilizations in the past dealt with the water purification problem, especially when there were no chemicals, factories, and water supply infrastructure. Through this research of literature, one water purification method used by the Indian farmers since ancient times to purify the water available in the ponds they dug to collect the rain water in each field was selected for testing. The rain water collected in those ponds was contaminated by wild life excrements, mud, algae, etc. and was not suitable for human consumption. The farmers made thin pads from dry straw available in the fields and used them as covers for the pot openings. When the pots are dipped into the pond water, these pads filtered out the large contaminants like algae, fecal matter, and heavy mud. Then these pots of water are taken out, mixed with the powder of Moringa Oleifera (drumstick) seeds, let them settle for about 30 minutes or so depending on the size of the pot. The Moringa Oleifera causes flocculation. In addition, the Moringa Oleifera seems to have anti-microbial properties that kill organic contaminants as well. This project tested the effectiveness of Moringa Oleifera as a flocculant. The results proved that the Moringa Oleifera is as effective as the Aluminum Sulfate. This solution is small scale, easily implementable in remote locations, and cheaper.

Comparison of effectiveness of Machine Learning algorithms for Vehicle Path Prediction

Sumanth R Moole (Thomas Jefferson High School for Science and Technology, USA)

In modern warfare, intercepting moving enemy targets such as tanks, aircraft, missiles, and drones plays a crucial role. These targets are either controlled by enemy personnel or by sophisticated electronic systems. Therefore, their movements are best characterized by random motion subject to certain physical laws. Predicting these motions is extremely complex and often requires continuous tracking through sophisticated radar equipment.

Machine Learning algorithms, such as Artificial Neural Networks, have proven to be effective in learning many real world motions of vehicles on the roads and have been extensively used in the autonomous vehicles. Artificial Neural Networks use activation functions to determine the output of a model from the given observations. After training the model with appropriate activation function, the model can be used for predictions. In this process, the activation functions play a crucial role. Selecting the correct activation function is critical to the success of the model.

This project simulates the moving enemy target using a BristleBot (a brush-head fitted with vibrating motor which generates vibrations in the bristles thus propelling the BristleBot) which moves on a flat surface. The motion of the BristleBot is digitized by recording the X-Y coordinates on the path it has taken from the beginning of the run to the end of the run. These runs are repeated and data from multiple runs is stored in a database. Using R Programming language, a neural network training algorithm is simulated where the activation function can be changed (slope-intercept linear

function - y = m*x + b - with various slopes and intercepts, quadratic function - y = a*x*x + b*x + c - with various a, b, and c values). The resulting models corresponding to each training session are compared with each other to find their similarity to the paths taken by the BristleBot. The effectiveness of these activation functions is then measured by the similarity score. The trained model (or the activation function) with best similarity score is then selected for predicting the future path of the BristleBot. This model then can be stored on a chip and interceptor vehicles can use it to predict the path and intercept the target.
This project is a simulation to demonstrate the usefulness of the Machine Learning algorithms (especially, Neural Networks) to train the models and store them on a chip that can guide the autonomous drones and missiles where sophisticated radar and satellite equipment are not feasible to guide them more accurately. Small inexpensive drones can be equipped with these chips to predict the paths of moving targets. Swarming with such drones is more economical in intercepting the targets. The simulation results with BristleBot are analyzed and similarity scores are obtained for different functions. These results indicate a reasonable effectiveness of quadratic functions for path prediction. The poster describes the simulation, linear and quadratic functions and their similarity scores, and the further research.

Faraday's Motor and Electromagnetism

Vanisha S Nagali and Saniya Nagali (Allentown High School, USA)

Michael Faraday's apparatus was a feat in engineering, applying the new learnings of electromagnetism and connecting it to motion. This discovery revolutionized transportation, providing a basis for the sophisticated motors we have today.

Hans Christian Ã˜rsted had discovered that the addition of electric current flowing through wire, would generate magnetism. AndrÃ©-Marie AmpÃ¨re expanded on this discovery to state that said magnetism would produce a circular magnetic force, developing a cylinder circling the wire. Isolating the magnetic pole would cause the electrically-charged wire to move in a constant, circular motion. Faraday used this knowledge to develop the first electric motor, created in 1821, just a year after electromagnetism was discovered.

The original motor was composed of a wire hanging down into a glass vessel, having a permanent magnet secured to the bottom. Said vessel would also contain an electrified mercury pool; the entire apparatus would be connected to a battery. This mechanism spun the wire in a clockwise movement, revolving about the battery.

One can experiment with the principles of Faraday's motor by building a homopolar motor. A homopolar motor is composed of a AA battery placed atop two neodymium magnets and a copper wire. The copper wire is formed into a coil - having one side touch the positive end of the battery, and the other in contact with one of the magnets. The battery should be within the coil, so the wire can orbit it.

The rotational movement of the copper wire is due to the Lorentz force - the effect of the electromagnetic fields produced through the battery and magnets. Current passes through the positive terminal into the copper wire, which transfers it to the magnet and back to the battery, and thus, the circuit is complete. When the magnetic field is perpendicular to the current - from the copper wire - the Lorentz force is generated, prompting the perpetual circular motion of the coil. During my presentation, I will demonstrate how homopolar motors can be built, using limited materials in a classroom, to demonstrate electromagnetism to students of different age ranges.

Although Faraday's apparatus cannot be directly found in modern technology, the creation transformed many aspects of engineering. Being the first electric motor, it was the foundation for the motors in cars, boats, and other forms of transportation.

Saturday; March 13, 2021 11:30 - 12:30

Full Paper Presentation - Midday Session

Works-In-Progress I

Understanding Object-Oriented Programming with a Game Engine Platform Transforming from 3D to Text-based coding

Sean Yang, Hyesung Park and Hongsik Choi (Georgia Gwinnett College, USA)

It is critical to balance fundamental programming concepts and coding skills to develop a skilled IT workforce who can solve a complicated real-life problem using technology. Students in an intermediate programming course faced challenges because programming is more than knowing programming language syntax and applying their thoughts into logical processes with appropriate data structures. Students who struggled often expressed that it is hard to visualize how a computer follows the program statements and loses interest.

We research active learning methods to determine what teaching methods worked best for our students and keep them in the classes through this project. We conveyed multiple learning methods, including learning by collaboration, flipped class, creating a video game, and combining those teaching methods. We also traced long term effects on students' learning.

Open Research Laboratory for Non-Research Focused Institutions

Michael Brown (University of Maryland Global Campus, USA)

Over the last few decades financial pressures on educational institutions have forced faculty to teach more classes taking time away from other activities including research. But research is important to institutions, faculty and students. This paper proposes for the creation of a non-profit entity that through donations could pool institution, faculty and student resources across multiply intuitions to conduct joint research. This would allow institutions, faculty and students to be active in research within the time constraints that they currently have. Research shows that this increase in research would have numerous benefits to students, faculty and institutions and promote interuniversity and international cooperation.

Teaching and Learning about Pendulums in RoboPhysics

Ofer Danino (Technion, Israel); Gideon Kaplan (Ministry of Education & Israel, Israel); Itamar Feldman (Ministry of Education, Israel)

RoboPhysics is an interdisciplinary educational program for teaching and learning Physics, combined with Engineering and Mathematics. It is based on Constructivist principles (using Project Based Learning), coupling of our senses & sensors to Physics theorems, and team work. Its main goals are the development of students inner motivation and systemic high level thinking. It is targeted both for middle High School students, as well as High School students studying for matriculation in Physics in the Israeli education framework. This short article depicts the teaching and learning process that we adhere to, by focusing on one important learning subject: the Pendulum.

Revolutionizing Engineering for P-12 Schools (REPS)

Tanner J Huffman (The College of New Jersey & Advancing Excellence in P-12 Engineering Education, USA); Greg Strimel (Purdue University, USA); Elizabeth Parry (STEM Education Insights, USA); Malinda Zarske (University of Colorado, Boulder, USA); Rebecca Turner (The College of New Jersey, USA)

Leveraging the investment in previous work, The College of New Jersey, Purdue University, and the American Society for Engineering Education has launched the three-year collaborative research Revolutionizing Engineering for P-12 Schools project. The REPS project investigates how to best implement engineering learning as defined by the Framework for P-12 Engineering Learning. As put forth in the framework, "associated grade-band specific implementation guides will leverage the content of this report to describe and propose appropriate engineering learning across the grades for all children to engage in rigorous and authentic learning experiences to think, act, and learn like an engineer". The Framework set the conceptual organization for P-12 engineering learning and provided preliminary Engineering Literacy Expectations and Engineering Performance Matrices for high school learners. Leveraging this roadmap provided in the Framework, REPS completes the vision by adding the Preschool (P)-Grade 8 components. The REPS project engages the broader P-12

engineering education community in articulating expectations for engineering learning for early learning, elementary, and middle school students to serve as the connecting elements necessary for authentic engineering learning efforts across the grades. The REPS project brings to bear the combined expertise of educators, professional engineers, and researchers in the field of engineering education to refine and complete a consensus on the nature of engineering literacy development for all students from preschool through high school.

A Case Study: Individual Design Enhancement for a Saucepan. Providing Practical Experience Within a Community College Engineering Program

Pamela Bogdan (College Dr & Ocean County College, USA); Derek Alton (Ocean County College, USA)

In this paper, the authors present the evolution of the Ocean County College (OCC) Engineering & Technology Program as it expands to include more career focused experiential learning opportunities. The goal is to provide students at our institution with opportunities to gain career-style experience that they can leverage to gain future employment. Observations and key findings about the use of experiential learning are provided based on a case study that is given from the perspective of the educator/mentor and the student. All of this is done in the context of an engineering project to create a prototype of the student's design for a single multi-configuration cooking pan.

Full Paper I

A STEM Program Designed, Developed and Delivered for Upper Primary School Pupils in Singapore
Lee Kar Heng (TBSS Center for Electrical and Electronics Engineering & Cong Ty TNHH Cong Nghe va Giam Sat Radar TBSS, Singapore)

In Singapore and many countries, students have avoided doing STEM courses because it is more difficult to read such courses and the job remunerations are not as well as other courses after graduation. The country is currently experiencing lack of good engineers, technologists and scientists [1], [2]. TBSS started an initiative to introduce STEM to students at young age in both fun and effective learning way from 2017. Team TBSS designed and developed a 6-hour STEM targeting upper primary school pupils aged between 10 and 12 years old who are reading from primary 4 to primary 6 in schools. The program has been conducted several times with Henry Park Primary School. The process, findings and experiences will be shared in this paper.

Assessment of Systems Requirements Specification Skills Based on an Industry Body of Knowledge

Andres Fortino (NYU & Autonomous Professional Development, USA); Tanusha Virodula (NYU, USA)

Contribution - The acquisition of systems requirements knowledge and skills by systems developers is a desirable outcome of a STEM graduate program in technology management. The result is not necessarily to create certified students (although that is certainly desirable) but to confirm that the program helps students acquire the necessary competencies as outlined in an industry standard. We present a process to align the program curriculum with an industry-standard to ensure those competencies. We describe a path for alignment of programs to develop other desirable competencies and our experience with the process.

Background - We selected the International Institute of Business Analysts (IIBA) as a vendor-neutral book of knowledge and, knowledge structure for BA (Business Analyst) professionals as well as a well-developed credential in the profession. We used a well-documented process to align a university curriculum to the industry needs, following similar work for project management and data analytics.

Research questions - To align the curriculum to the IIBA BABOK, we asked: (1) whether students graduating from the program had acquired adequate business analysis and systems requirements competencies; and (2) If they had not, how the curriculum be modified to help students acquire those competencies.

Methods - The curriculum was reviewed, and we assured initially that topical coverage of the pertinent course of study aligned adequately with the IIBA BABOK (Business Analysis book of Knowledge) knowledge structure. Results - Using the existing curriculum, we found that a majority of the students were able to pass the assessment based on the IIAB BABOK at the end of their program of study. The exam results were sufficiently granular to allow us to make modifications to the curriculum and course contents to improve the passing rate in future trials.

Using Coding Competitions to Develop STEM Skills in Graduate Education

Andres Fortino (NYU & Autonomous Professional Development, USA); Maria Rivera (NYU, USA)

Contribution - We present the results of the development and implementation of an extra-curricular process to assist university students to develop skills in data analysis. We offered coding workshops in R and Python. To motivate the

students to participate in learning and to practice the learned skills, we set followed a learning workshop with a contest on text data mining.
Background - University credit-bearing education is often streamlined to cover increasing amounts of subject matter knowledge in class. It is not usually possible for faculty to take time from their curriculum to develop basic analytics skills, such as the use of R or Python for business analytics. Extra-curricular skills-building activities are an effective vehicle to develop these skills outside class.
Research questions - Do extra-curricular workshops to learn coding result in successful learning? Would a coding contest after the workshop drive attendance? What are the elements of a successful workshop and coding contest, and what are acceptable metrics and levels of performance for these contests?
Methods - Coding workshops were developed and offered as extra-curricular opportunities for students in a STEM graduate program. After the coding workshops, short-duration coding contests were launched. The goal of the contest was to develop text analytic tools that could be used by the students to advance their academic careers. Attendance in the workshop as a percent of the student body and quality and number of coding contest submissions was a metric of success. Contest participation and successful submissions were a second metric.
Results - Two workshops were run with concurrent contests. An average of 10% of the student body registered, and 5% attended. Contest submissions were received, and in each case, at least one submission yielded a usable tool. The tools were subsequently used by students in their job search and to conduct research.

Educating & Training STEM IT Professionals Based on the CDIO Standards Evolution

Alexander Zamyatin (Tomsk State University, Russia)
Today, the development and implementation of integrated STEM education is one of the up-to-date challenges for pedagogical theory and practice. There is a large body of research devoted to this issue, especially in relation to K-12 STEM education (Kelley et al., 2016; Shernoff et al., 2017; Goodwin et al., 2017; Thibaut et al., 2018; Struyf et al., 2019; Hinojo-Lucena et al., 2020; Ortiz-Revilla et al., 2020; Wang, et al. 2020), but also higher education (Flynn et al., 2014; Langie & Pinxten, 2018; Margot et al., 2019; Winberg et al., 2019). However, researchers pay little attention to the coordination of education & training of university graduates in various fields (science, mathematics, engineering, technology) for future joint work in multidisciplinary teams. At the same time, coordinated education & training of professionals in various STEM fields for multidisciplinary teamwork is extremely important, since most innovations are born on an interdisciplinary basis, and maximum productivity and efficiency of teamwork is achieved through the division of labor in the joint activities of STEM professionals. The fact is any university graduate from a certain major, having even the best integrated STEM education & training, is not able to solve a complex real-world problem alone. It can and should be solved by team of professionals in various fields of knowledge & activity, having interdisciplinary education & training for a better understanding of the problem complexity, as well as each other when working together.

Comprehensive analysis of IEEE 802.11ah for Wireless Communication Networks

Aws Zuheer Yonis, Abdulrahman Tareed and Hamza Dweig (Ninevah University, Iraq)
IEEE 802.11ah is an approved amendment to IEEE 802.11 wireless local area network (WLAN) standard to support growing demand for machine-to-machine (M2M) applications. IEEE 802.11ah is intended for extended range and low power applications in the unlicensed sub 1 GHz band, including machine to machine communication and the internet of things. 802.11ah uses narrower contiguous channel bandwidths than IEEE 802.11n and IEEE 802.11ac to facilitate long range, low power communication at a lower data rate. Valid channel bandwidths are 1, 2, 4, 8, and 16 MHz IEEE 802.11 ah standard was originally targeting high throughput applications. However, being able to have IP connectivity and the fact that Wi-Fi have already spread in every corner of the world, make this standard one of the most suitable technologies for next generation techniques. The paper evaluates the performance of IEEE 802.11ah and some of its features in various scenarios in this research work.

Full Paper II

The Science and Technology Wing: An Experiment for In-residence STEM Undergraduate Education
Jorge Santiago-Aviles and M'hamed Bokreta (University of Pennsylvania, USA); Geraldine Light (Walden University, USA)
In this article, we relate the story and the guidelines for a STEM program now spanning more than three decades. The program, called the Science and Technology Wing, is mostly populated by engineering and physical sciences majors. The

undergraduates enthusiastically participate in the technical developments highlighted by the faculty in the central research laboratories, bringing their newly acquired knowledge and familiarity to the college house projects facilities to share with their peers, staff, and guiding faculty. The experience so gained served the students in developing state of the art knowledge and experience in the technology of the day and its related science fundamentals. Over the three decades the topics the participants explored engineering related to gardening, business, social science, math, computer science, robotics, entrepreneurship, and humanities. With proposed experimental and theoretical projects being assessed in house by the participants for relevance to the residence infrastructure and supported by fellowship funds.

Implementing Blended Learning in K-12 Programming Course: Lesson Design and Student Feedback

Shuhan Zhang (The University of Hong Kong, China); Chunyu Cui (Tencent Education Center for Innovation and Cooperation, China)

Computational thinking (CT) has been widely integrated into K-12 classrooms through programming education. Although numerous initiatives have been developed to lower down the threshold for learning programming, instructors may still feel ill-prepared. Blended learning approach, a combination of student-centered learning and teacher-centered instruction, has proved to be an effective delivery mode for K-12 programming course. With the purpose of providing practical insights for the design of blended programming class, this study introduced an instructional unit of a K-12 programming course in a secondary school in China. It elaborated the course regarding lesson design, learning assessment, and course evaluation. The course contains 9 plugged sessions and 24 unplugged sessions, and each session consists of 1) a preview to introduce the concept, 2) hands-on activities to apply the concept, and 3) a summary or sharing of ideas. Student learning was evaluated with performance-based assessments, and questionnaire was employed to collect students' feedback and attitudes towards the course. The results show that students with low performance were the most beneficiaries of the course, and students tended to like visual programming tool and stage-mode learning format. Also, students with different learning backgrounds showed different preferences for the course materials. Suggestions are provided for further research and course design practices.

Math & Crafts, Educational Activities: 400 Indigenous Kids Learning Math from Engineers and Scientists

Ernesto Vega Janica (IEEE Standards Association, USA)

This paper discusses the planning and implementation stages involved in teaching a math class, in full compliance with local educational programs, plus additional content based on native/indigenous numerical systems. The educational program includes a combination of theory and practice to help kids appreciate technical concepts by their own means and methods, as well as providing a wide-range of learning possibilities for other applications. These "Math & Crafts" activities will be implemented in five schools within the Arhuaco School System; an indigenous community of approximately 30,000 people. 400 children in 5th grade of elementary school will be our initial audience. Future projects are expected to include reaching out to urban classmates. Furthermore, the intent of this research is not simply to evaluate the use and adaptation of native numerical systems, but also to help preserve ancient knowledge, culture and language from multiple native civilizations. The research intends to monitor students' progress and skills with minimum interference of their native culture. The intent is to monitor three school year cycles from January of 2021 to December of 2023.
Note: due to COVID-19 global pandemic, prerecorded and remote classes will be provided.

Asymptotics for Iterating the Lusztig-Vogan Bijection for GL_n on Dominant Weights

Yuxiao Wang (Princeton International School of Mathematics and Science, USA)

The Lusztig-Vogan Bijection, conjectured independently by Lusztig and Vogan and proved by Bezrukavnikov, is a correspondence between the set of dominant weights for any reductive group G over an algebraically closed field and the set of irreducible G-equivalent bundles on nilpotent orbits. This bijection plays a crucial role in proving the Humphreys conjecture on the support varieties of tilting modules for quantum groups at unity. Bezrukavnikov's method of establishing the Lusztig-Vogan Bijection, however, is highly inexplicit and non-elementary. Recent efforts have been focusing on understanding the bijection in an explicit way and in combinatorial contexts. Achar suggested an algorithm for computing Type A Lusztig-Vogan Bijection (i.e., for $GL_$n), and his algorithm is greatly simplified by Rush.
In this paper, we will pursue a new direction: we will iterate the algorithm proposed by Achar and Rush. We first present some basic properties of Type A Lusztig-Vogan Bijection and its iteration. Then. we explore the iteration on inputs of small length (2, 3, and 4), and the complexity of the result motivates us to modify the way of measuring the iteration for large inputs. With our new definition, we prove the asymptotic behavior between the number of iterations for input and the length of the input and obtain a recursive formula to compute the slope of the asymptote. Finally, we propose two possible directions to continue the work in our paper. The paper serves as another contribution to understanding the

Lusztig-Vogan Bijection from a combinatorial perspective and a first step in understanding the iterative behavior of the Type A Lusztig-Vogan Bijection.

Broadening Participation in Computer Science through Sheltered Instruction Pedagogy

Patricia A Morreale (Kean University, USA); Mayra S Bachrach (1000 Morris Ave, USA); Gail Verdi (Kean University, USA)
Sheltered Instruction (SI), based on second language acquisition research, has been used to explore pedagogical interventions aimed at improving the outcomes of English Language Learners in Advanced Placement Computer Science (AP CS). 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. During this year-long project, AP CS teachers attended a series of professional learning workshop on SI for Computer Science, and then utilized strategies from SI in their AP CS classrooms. Research outcomes of the pedagogical interventions identified new approaches to engage all students, through SI methods and materials used with the computer science curriculum. The SI pedagogy integrated with CS teaching skills shows how teachers can successfully engage more students in their classrooms, particularly students that may still be developing their academic English language skills, increasing CS education for all students. The SI methods used are explained here, for adoption by other computer science educators and researchers.

On the Generational Behavior of Gaussian Binomial Coefficients at Roots of Unity

Yuxiao Wang and Quanlin Chen (Princeton International School of Mathematics and Science, USA)
The generational behavior of Gaussian binomial coefficients at roots of unity shadows the relationship between the reductive algebraic group in prime characteristic and the quantum group at roots of unity. In this paper, we study three ways of obtaining integer values from Gaussian binomial coefficients at the roots of unity. We rigorously define the generations in this context and prove such behavior at primes power and two times primes power roots of unity. Moreover, we investigate and make conjectures on the vanishing, valuation, and sign behavior under the big picture of generation.
We will first present some useful tools in relating the integral q-binomial coefficients with usual binomial coefficients as well as interesting combinatorial objects in their own rite. We will then present our main result, formulating and proving a generational relationship between these integral q-binomial coefficients and usual binomial coefficients mod p. Finally, we will discuss the related combinatorial properties of integral q-binomial coefficients and their cousins with our definition in the first part.

Full Paper III

An Examination of Industry Standards of Success within Penetration Testing Groups

Mollie Ducoste, Rachel Bleiman, Trinh Nguyen and Aunshul Rege (Temple University, USA)
Penetration testing groups can be used as an ethical proxy to study cybercrime groups, as both parties share the common goal of identifying and exploiting weaknesses in their targets' systems. In particular, this study examines college students' experiences while participating in the 2018 and 2019 National Collegiate Penetration Testing Competition (CPTC), which simulates a professional, real-world penetration test. Metrics from industry standards of pentesting practices are compared to the metrics identified from the experiences of the CPTC participants, revealed through semi-structured group interviews. Industry metrics include standards such as methods, information gathering, attack generation, quantity of findings, quality of findings, and reporting of findings. Additional metrics identified from the CPTC participants include skills of the team, the environment, expectations, and the relationships among group members. This study aims to examine the metrics of the successes and failures of penetration testers, which serves as a way to better understand the operations and processes behind the execution of cyberattacks.

Curriculum to Broaden Participation in Cybersecurity for Middle School Teachers and Students

Laurin Buchanan (Secure Decisions, USA); Lori Scarlatos and Nataliia Telendii (Stony Brook University, USA)
To both broaden and increase participation in any STEM field such as cybersecurity, we need to attract more students. Research shows that to do this, students need to be engaged with cybersecurity during middle school. There is a lack of age-appropriate and classroom-ready cybersecurity curriculum, however, and many teachers feel unprepared to teach the subject. To address this gap, the CyberMiSTS project team created a summer professional development workshop for middle school teachers that integrated a recent research-based understanding of cybersecurity into a curriculum that is accessible to both middle school students and their teachers. The project sought to encourage participation of a broad

and diverse set of students in the field of cybersecurity by showing them how human relations play an important role in cybersecurity. We discuss our prior related work using branching web comics to introduce middle school students to cybersecurity concepts and careers, and the state of evidence-based research into effective approaches and methods for cybersecurity education. We identify challenges to broadening the pipeline for a truly diverse cybersecurity workforce that can meet industry's need for cybersecurity professionals with a wide range of experience and skills. The paper introduces our approach for the teacher professional development workshop, maps how we designed the project to meet our research goals, and documents initial findings regarding what is needed to increase teacher self-efficacy about cybersecurity concepts and careers in a middle school classroom.

BEAT: Branding and Entrepreneurship of Assistive Technology for Social Good

Zhigang Zhu (The City University of New York, USA); Gerardo Blumenkrantz (The City College of New York, USA); Katherine Olives (Zahn Innovation Center, USA)

This paper describes the opportunities and challenges found in incorporating both branding and entrepreneurship components into an engineering senior design course (Capstone course). This newly upgraded course is called BEAT: Branding and Entrepreneurship of Assistive Technology. The original joint senior design course on assistive technology has been run for over ten years, serving undergraduate seniors in computer science, computer engineering and electrical engineering at CCNY, working on assistive technology projects to help people in need. The class had informally included entrepreneurial components in the past, but from 2019 on, we formally integrated both branding and entrepreneurship components into the curriculum. This paper describes the motivation of the work, the four key components in the course syllabus, a number of student evaluation mechanisms, course outcomes so far and results of a student survey, and some final discussions of the opportunities we provide to our students and challenges we face in implementing this cross-disciplinary curriculum.

Augmented Running

Shane Murphy and Mihir Patel (US Military Academy, USA); John R Rogers (USMA, USA)

This paper details the on-going research to analyze and simulate the metabolic effects of running with mechanical assistance. A subject was augmented with bungee cords and ran on a treadmill; the subject's O2 and CO2 were monitored. The subject was fitted with markers and motion was captured with an IR camera system. Ground reaction forces measured by the instrumented treadmill were recorded. From pilot VO2 / CO2 data, the group found that O2 consumption is significantly reduced with augmentation, as predicted. The effect is like running downhill. The team is currently learning to simulate the body and the effect of external forces using the OpenSim program. Immediate future work is to incorporate the bungee forces in an OpenSim simulation to predict metabolic rate. Involvement in research has had multiple educational benefits for the students. They have understood haw classroom theory applies in the laboratory. They have developed a sense of the complexity of research work.

Taking STEM Enrichment Camps Virtual: Strategies & Reflections from Quick Pivot due to COVID-19

Rebecca Lowe, Adrienne Smith and Christie Prout (Cynosure Consulting, USA); Guenter Maresch, Christopher Bacot and Lura Sapp (North Florida College, USA)

Since COVID-19 began spreading in the US and quickly established as a global pandemic in March of 2020, the NSF-funded STEM SEALS team at North Florida College faced the touch decision to either cancel their inaugural hands-on STEM enrichment camp planned for Summer 2020 or rushing at full speed to take it virtual. The biggest concern in making the decision to go virtual was a passionate belief in the importance of not losing the hands-on focus that had been planned. After all, the STEM SEALs effort at NFC was designed to expand access to high quality STEM experiences for historically underserved students in a high poverty, rural area. Changing from the in-person delivery to distance learning with minimal preparation presented a daunting challenge and also a unique opportunity; the opportunity to study the process and provide guidance to other STEM providers who are considering a move to a virtual platform. This exploratory study aimed to (1) identify the barriers to moving STEM enrichment programming in a rural environment from in-person to virtual activities during the COVID-19 pandemic, (2) describe key decisions that were made in transitioning to the virtual format along with the rationale behind those decisions, and (3) disseminate best practices that emerged from the inaugural effort.

Saturday; March 13, 2021 12:30 – 1:30

Workshops

Objective Model for Improving Learning Outcomes

Rodney Leonard Bollie (USA & Institute of Basic Technology, USA)

When it comes to teaching STEM in economically challenged communities, the tendency is to focus largely on the lack of the immediate such as the physical logistics, laboratory equipment, staffing, coding expertise, etc. However, the context and the unique, not necessarily academic, elements that impact learning outcomes are seldom taking into account.

The objective model being developed by the Institute of Basic Technology, seeks to statistically measure the contributing effect of five (5) discrete impediments to teaching STEM. The model measures the impact of the following:

1. Impact of limited vocabulary
2. Impact of a mother's education
3. Impact of access to educational material
4. Impact of a large family
5. Impact of affirmation (encouragement)

Early results are starting to indicate that if a mom has at least a high school education, there is a high probability (~70-80%) that the student's academic outcome will trend toward academic excellence. The converse is true for a mom with no education. In such a case, the guidance is to provide additional support to students in such cases.

The impact of a limited vocabulary is high right up there behind the mother's education. Limited vocabulary does impact reading comprehension and can negatively impact the student's academic outcome by a probability of about 85-90%. The other impediments are shown in order of decreasing probabilities. The caveat here is that it is still too early to say with statistical certainty how reliable these number are.

However using these early indicators as guidance and making some modifications to our STEM program for the institutions our lab partners with, we are beginning to see successive academic improvements in students performance from year to year.

Creating Community Support for Mathematics Literacy

Lauren Siegel (MathHappens Foundation, USA)

MathHappens Foundation plans to launch a post covid one year mathematics education campaign that includes partnering with libraries and other centers of community education including museums, cultural centers, and nature centers. We will also continue to place mathematics in the newspaper, continue to support the work of other public projects.

Pursuit of a One year multi- pronged Strategy in Libraries

Now:

Create theme or concept take home kits that contain a hands on activity and book or mathematics games.

After Covid:

1) Fund in-person learning with a Mathematics help desk open to any member of the community, two days per week serving k-12 students their parents and caregivers and others.

2) Place critical models and exhibits like platonic solids, a unit circle display, and pythagorean puzzles and more in libraries

3) Create, staff and deliver regular family programming on mathematics topics by theme.

4) Advocate for and support with $ schools that reach out to and collaborate with their community to improve public math literacy.

Strategy for Museums

Collaborate with museums to add mathematics connections to labeling and exhibit presentations as well as usual public programs. Sponsor mathematics field trips.

We need more opportunities to learn mathematics, caregivers and parents need to learn and we have to ask ourselves

how we can encourage curiosity, enthusiasm to learn and the positive attitudes we will need to make up for lost learning and approach the future with confidence.

Aligning Secondary Programs to the Framework for P-12 Engineering Learning

Tanner J Huffman (The College of New Jersey & Advancing Excellence in P-12 Engineering Education, USA); Greg Strimel (Purdue University, USA); Amy Sabarre (Harrisonburg City Public Schools, USA); Michael Grubbs (Baltimore County Public Schools, USA); Jamie Gurganus (University of Maryland, Baltimore County, USA)

The recently released Framework for P-12 Engineering Learning (www.p12framework.asee.org) was developed through a synergistic collaboration of teachers, school administrators, and researchers alongside the leaders of the Advancing Excellence in P-12 Engineering Education (AE3) research collaborative and the American Society of Engineering Education (ASEE). The framework provides practical guidance by identifying common P-12 engineering learning goals that all students should reach to become engineering literate. The Framework aims to add structure and coherence to the P-12 engineering community by serving as a foundation for the development of any and all engineering programs in schools, informing state and national standards-setting efforts, and providing the research community with a common "starting point" to better investigate and understand P-12 engineering learning. During the development of the Framework, two large and diverse school systems, Baltimore County Public Schools (MD) and Harrisonburg City Public Schools (VA), worked alongside the research team to implement, align, trial, and provide feedback on the preliminary Engineering Literacy Expectations and Engineering Performance Matrices for high school learners (www.p12engineering.org/epm). This workshop will introduce participants to (1) content presented in the Framework (e.g. engineering habits of mind, practices, and knowledge), the framework development process, and framework resources; as well as (2) the implementation models each district used, how they garnered teacher and school-level administration buy in, and what areas to focus on to institute transformative change. This workshop is best suited for P-12 teachers of STEM education, school and district level administrators, and researchers interested in investigating engineering learning in P-12 schools.

STEM, STEAM and STREAM Education

Naresh Chand, Fellow IEEE

No Abstract Information

Application of the System Development Life Cycle Model (SDLC) to Everyday Tasks

Gennaro Avvento (Gennaro J. Avvento Technical Services LLC & Lockheed Martin (Retired), USA)

Overview of Workshop Concept

This workshop is inspired by our work in improve team performance using lesson learned techniques from industry and adaptation of the SE SDLC concepts to the BEST robotic competitions.

The workshop will consist of three session, each building on each other. Three key sessions initiatives are part of look at demonstrating the value of system engineering and in particular SDLC concepts to educators, and its use in everyday problem. Specifically, these initiatives are:

Session 1. (30 minutes) SE Foundation Workshop
In this workshop we teach the participant about the concept of thinking like systems engineer and to the concepts of systems engineering - in terms that they can understand and relate towards. This solid baseline will be the basis for the introduction of the value of system engineering thinking in everyday classroom activities, not just for use on specific engineering problems. This workshop is based on the concept of teaching the teachers first, and for them to introduce the concepts of systems engineering to their students; The content of the workshop will provide an overarching introduction to systems and systems engineering thinking
Session 2. (30minutes) Application of the SDLC to Practical Problems
In this workshop we will introduce participants to the value of using the SDLC model to address many everyday problems. i.e., Creating a book report, making a peanut butter and jelly sandwich, taking a trip. These examples will emphasize the SDLC thinking pattern.
Session 3. (30 minutes) Application of the SDLC towards Selected Problems
This section will discuss how to tailor the SDLC to a unique set of tasks. Each participant will select a set of tasks or small

project and tailor the SDLC to fit their needs. The instructor will coach the participants when help is needed. Each participant will walkthrough their adapted SDLC to the session participants.

Presenters; Gennaro J Avvento, is a Lockheed Martin Technical Fellow Emeritus (Retired). He holds an Expert Systems Engineering Professional Certification from the International Council of System Engineers (INCOSE). Mr. Avvento is a graduate of the Air Force Academy. He holds advanced degrees from University of Houston Clear Lake, West Chester University Pennsylvania and Stevens Institute Technology NJ. He is President and CEO of G.J. Avvento Technical Services. LLC

Eric V. Sudano, is a Lockheed Martin Computer System Architect (Retired) He holds a Lockheed Martin Information System Architect Certification. He is a graduate of Rutgers University (1972) and a M.S. Applied Mathematics Rensselaer Polytechnic Institute (1974). He is President and CEO of E.V. Sudano Systems Solutions LLC.

The Influence of Entrepreneurship Knowledge on Entrepreneurial Interest

Ariyono Setiawan (Universitas Negeri Surabaya, Indonesia)

Entrepreneurship is the most important part of the process of building a country's economic growth. Entrepreneurship can also help the government provide many jobs, various community needs, services, and foster the welfare of a country. Besides, entrepreneurship is also a part of facing the challenges of globalization. The Indonesian economy is not in a good shape. This is because the Covid-19 Pandemic is currently sweeping the entire world, besides that at the beginning of this year or more precisely in January 2021 Indonesia experienced many disasters, ranging from natural disasters such as volcanoes, earthquakes, floods, landslides. until the plane crash disaster. The tragedy that was experienced further worsened the Indonesian economy. However, there are still many businessmen who donate money to help improve current economic conditions. This also reinforces that entrepreneurs have relatively stable finances. Therefore, the role of entrepreneurial knowledge and how to adapt to the era of the industrial revolution 4.0 and the pandemic that is currently hitting. Entrepreneurial knowledge must also be disseminated to the wider community, through education, seminars, workshops, and courses. Many business opportunities can still be developed through research in the market, and for this reason, knowledge of entrepreneurship is needed to carry out appropriate research for the development process. By facing various challenges in the era of the industrial revolution 4.0, as well as in an era that is currently experiencing the Covid-19 pandemic which can be one solution to be able to continue living is to carry out entrepreneurial activities. By having entrepreneurial knowledge, finally, someone can be interested in starting a business. From the description above, it can be concluded that knowledge about entrepreneurship can trigger one's interest in entrepreneurship.

Using MATLAB for STEM Learning

Mary Dzaugis (MathWorks, USA)

MATLAB combines math, simulation, and programming in an environment that is easy to use and get started. In this session, you will learn how you can use MATLAB to accelerate the pace of STEM discovery and learning in the classroom. We will share interactive STEM activities, using use the same tools that scientists and engineers around the world use to solve problems and innovate. From math lessons to robot simulations, we will explore how these computational tools can be used to encourage students to think like engineers and scientists.

MathWorks™ develops computational tools that enable scientists and engineers to explore and innovate. MATLAB is one of the top 10 most popular programming languages and is used for teaching, research, and project-based learning. Add MATLAB and Simulink to the classroom to inspire critical thinking and innovation as well as prepare students for prominent careers in industry. Learn about MATLAB and Simulink in Primary and Secondary schools at www.mathworks.com/academia/highschool

Saturday; March 13, 2021 1:30 – 3:00
Paper Presentation - Afternoon Session

Full Paper IV

A new method for disinfection and sterilization of air and objects using an electrified mist

Helena Ai He and Kenneth He (Princeton International School of Mathematics and Science, USA)

The COVID-19 virus has become a major global challenge. Thus, a safe and efficient method for disinfecting air and objects is needed. My novel method revolves around using an electrified mist produced by an ultrasonic mister using a pure water and ozone solution. The mist particles carry static electricity (negatively charged), which can absorb airborne dust, viruses, or germs; dissolved ozone can then kill the viruses or germs. As the water evaporates, the dissolved ozone completely decomposes into oxygen, which is not harmful to the human body. This mist will be dispensed by a device similar to a humidifier. When this equipment is placed indoors, people can communicate at close distances without wearing masks, have meals at the same table, and speak and sing freely. I plan to conduct skin and respiratory tract disinfection tests, which are of great significance to preventing COVID-19.

If two veils of mist with different polarities (negative and positive) are used, they will attract and continuously discharge in the air. Upon spraying this mist on objects, the mist particles will deposit on the surface of the object, forming a thin water film. Similar to thunderstorms, there will be a large number of negative ions generated, which will adsorb viruses or germs. This is similar to the pulsed electric field sterilization technology in food processing. The mist particles can discharge with electric field strength 10-50kV/cm, pulse width 100μs, and pulse frequency up to 2000Hz. This destroys the cell membrane or virus surface protein structure. Theoretically, my method can also be safely used for the disinfection of the face, hands, and respiratory tract. Currently, two prototypes are being assembled, and a series of experiments will be carried out. Preliminary tests have shown that the average sterilization rate of the electrified mist exceeds 91% efficiency.

Understanding electronics and CT in school - a simplified method for drawing and building electronic circuits for the micro-bit and breadboards

Bjarke K M K Pedersen, Jacob Nielsen and Jørgen Larsen (University of Southern Denmark, Denmark)

Worldwide we see an increasing focus on implementing STEM, CT and Educational Robotics, within K-12 curricula and the British BBC and the Danish DR, have provided more than one-million pupils with the micro-bit technology. However, research show that breadboards and circuit diagrams, can be difficult to understand. In this paper, we have evaluated a set of tools and materials - designed to support the teaching of electronics and CT, for use with micro-bits, breadboards and circuit diagrams - by integrating them in a case study of a robotics course for 7th grade primary school pupils (n=21). The tools and materials consist of 3D-printable covers designed to visualize the internal connections of a breadboard, and a new type of circuits diagrams, incorporating visual cues from the these, into their designs. Results show that the tools and materials ease the learning of the breadboard and of how to use and interpret circuit diagrams. Furthermore, the tools and materials, have been made available free of charge.

Training Workers to Thrive in Future Technology-Driven Environments: A Blueprint

Wenbing Zhao (Cleveland State University, USA)

The rapid development in machine learning and artificial intelligence will inevitably make most workplaces into technology-driven environments where workers will be forced to use and rely on various technologies. In this paper, we outline two major challenges a non-tech savvy worker will face in such future work environments. The first challenge is the fear for technology, which is often termed as "technostress." The second is the lack of leadership skills. While the first challenge has been well-recognized, few industry sectors have recognized the need to offer leadership training for all its workforce. In future, the works will inevitably be more sophisticated and they will require the workers to have the skills to handle unexpected situations, especially on tasks related to working with customers because simple and repetitive tasks will have been automated by machines. To overcome these issues, we propose to provide individualized training for workers using carefully designed educational modules that are themselves backed by artificial intelligence. Essentially, artificial intelligence would be put to use to study patterns of human behaviors and identify the most effective ways to intervene that could alter human behavior for better.

Retention of Undergraduate Women in Engineering: Key Factors and Interventions

Wenbing Zhao and Xiongyi Liu (Cleveland State University, USA)

In this paper, we present a concise review regarding factors that impact the retention of undergraduate women in engineering as well as interventions that aim to boost female student academic performance and retention rate. We

divide these factors into two types: individual factors, and environmental factors. The former refers to the student's characteristics. The latter refers to factors that could impact a student via social interaction. The core theories for individual factors include the self-determination theory, the expectancy-value theory, and the self-efficacy theory. An important theory on the environmental factors is the social capital theory. The primary individual factors include self-efficacy (competence belief), sense of belonging (relatedness), sense of autonomy, belief about worth, academic preparation, engineering identity. The primary environmental factors include social capital, family role, friends role, peers role, faculty role, level of advising and support, and stereotypic attribution bias. The various intervention programs that aim to boost student academic performance, retention, and persistency are designed to help strengthen student characteristics and provide a more conducive social environment for the student to excel in engineering. We classify the intervention programs into five categories, including mentoring, co-op, living learning, contextual support, and pedagogy.

Augmented Reality Technology Projects of Tea Culture for China's Secondary Students

Hongyu Chen, Dan Sun, Xue Zhang and Yan Li (Zhejiang University, China)

AR technologies has becoming an uprising yet challenging technology to foster K-12 students' learning. Previous research has reported contrasting but positive conclusions about the effect of integrating AR technology in science, technology, engineering and mathematics (STEM) education. This research selected tea culture, which is a profound and long-lasting culture in China and the world, and designed and developed AR tea culture resources to facilitate secondary student's learning. In order to further examine the effect of utilizing AR tea culture resources, this study designed a quasi-experiment and utilized a mixed-method approach to examine students' knowledge acquisition, learning experience, and learning attitude towards tea culture during instruction through AR project. The analysis results show that students in experimental group achieved a better grade in knowledge acquisition, and significant improvement in learning experience and learning attitude towards tea culture than students receiving lecture through traditional teacher-led PowerPoint instruction. It is becoming more necessary to educate future developers and educators of the development and integration of AR technologies in formal education, where our experience could provide some implications for future STEM educational community.

Full Paper V

Experiences on Incorporating Market Experiments into Energy System Education

Bolun Xu (Columbia University, USA)

This paper summarizes an experience on integrating classroom electricity market experiments into a senior-level course in Columbia University: Energy System Economics and Optimization, which attracted a diverse student body covering various engineering programs as well as public policies and business school. In accordance with the virtual instruction method due to Covid-19, these experiments are assigned to students in the form of online quizzes. In these experiments, students role play electricity market participants by submitting bids or estimating future scenarios spanning topics including centralized market clearing, demand serving contracting, and wind power contracting. These experiments where performed using down-scaled real data from New York Independent System Operator, and the instructor will perform market clearing and analyze the results with the students. Experiences from this course show that these economic experiments attract students' attention and study interests especially at the beginning of the course, but also show rooms for improvements especially on better engaging student in more complex market settings.

Identifying Positive Catalysts in the STEM Career Pipeline

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

Science, Technology, Engineering and Math (STEM) professionals continue to be in demand throughout the world. Building this future workforce remains the focus of many educational and outreach organizations. To optimize these efforts, it is important to identify what positive influences and catalysts affect students as they move through the STEM career pipeline. Using survey findings of currently employed scientists and engineers reflecting on their journey through K-12 education to careers, beneficial interactions can be identified. These results point towards different catalysts having influences as specific phases in the career pipeline, with notable bright spots of family and teacher influence particularly for middle school and high school girls. These insights can provide direction for STEM education and outreach programs to better reach K-12 students, particularly those from underrepresented demographics, at pivotal transition points with

tailored multifaceted initiatives. These efforts can enhance self-perception and self-efficacy for students and help inspire those with career aspirations in STEM fields to continue pursuing their goals and become the next generation of problem solvers and innovators.

STEM-Coding Using Drones

Justine Horst (University of Wisconsin-Platteville, USA); Mehdi Roopaei (University of Wisconsin - Platteville, USA)
STEM learning from an early age is essential to confirm that students are prepared to meet the needs of the world they will inherit. Currently, there are incredible and inexpensive technologies to keep students engaged and passionate about their learning. A drone is a hands-on apparatus that could be incorporated in STEM for several learning applications such as class projects, experiments, and exploration. In this paper, the STEM-coding framework is designed for kids to learn coding using drone and Scratch programming. This platform attempts to visualize their coding by drone while Scratch makes a gaming environment to enhance their programming using block-based learning. The platform has applied in a STEM event at the University of Wisconsin Platteville and the results show the benefit of utilizing drone in STEM-coding as follows: i) transforms abstract concepts into concrete learning, ii) delivers an entertaining and motivating learning environment, iii) combines STEM theory with practice, and iv) provides a hand-on skill which is dynamic and attractive.

Adapting a STEM Robotics Program to the Covid-19 Pandemic - an application for Systems Engineering

Neville E. Jacobs (IEEE Baltimore Section, USA); Eric V Sudano (Eric V. Sudano System Solutions LLC, USA); Dwight Bues (SAIC Corp., USA); Gennaro Avvento (Gennaro J. Avvento Technical Services LLC & Lockheed Martin (Retired), USA); Ralph Tillinghast (US Army & CCDC Armaments Center, Picatinny Arsenal, NJ, USA)
At the 2019 ISEC conference, a paper was presented [1] that quantitatively described how the IEEE STEaM Robot Challenge project, based on hands-on teamwork and student interactions, leads students to improved learning engagement, and an increased interest in Engineering. After cancelling the event in 2020 due to the Covid-19 Pandemic, it was decided to re-design the project and research whether in the midst of current restrictions, improvements in students' learning engagement could still be obtained even when students would have to work from home and where teamwork could only be practiced on-line. The changes would need to provide a comparable Challenge in each of the four elements of the previous program, and would be validated by a student survey similar to the one conducted for the 2019 paper. Because the project needed to work right the first (and possibly only) time, it was decided to use System Engineering concepts for the re-design, so the project would then become a case study on the use of this technique in an educational setting. The lessons learned from this redesign, and the arrangements developed for the 2021 Robot Challenge competition, may not only be of value for those planning other competitions, but the new on-line system utilized could be readily adapted to reach students living in rural and underserved communities, thus providing them with the same learning experience as those living in metropolitan centers

Water Footprint at Schools with Arduino Project: STEM and Sustainable Development Goals

Otacilio Antunes Santana (Federal University of Pernambuco & DBR | PROFCIAMB, Brazil); Caina Silva (Federal University of Pernambuco, Brazil); Mayara Lima (Federal Rural University of Pernambuco, Brazil)
How can we measure the Water Footprint at Schools? The objective of this work was to apply an Arduino Project to measure water flow in a school context of reducing the Water Footprint to involve Sciences, Technology, Engineering and Mathematics (STEM) with Sustainable Development Goals (SDG). The work achieved its purpose, as it managed to apply an Arduino Project in school environments to assess the water footprint per capita. This project, together with the work of PROFCIAMB, managed to reduce the water footprint compared to schools that did not carry out this action. The interdisciplinary and innovative project involved STEM teachers and the whole school, creating a new way of using educational objects and devising strategies to reduce water consumption in some environments at the School. Students who reduced their water footprints obtained the highest marks in the National Exams. This proves how important it is to promote engagement in contextual practices. Thus, joining STEM and SDG was a successful alternative in the students' learning processes and for environmental purposes.

Immersive Technology in Integrating STEM Education

Mehdi Roopaei (University of Wisconsin - Platteville, USA); Emilee Klaas (1 University Plaza, Platteville, WI, USA)
Educators are often faced with the challenge of exposing students to new environments and information in an educational and timely manner. The use of immersive technology in a classroom allows teachers to expose students to simulations or conditions that could be difficult or not possible to explore without this technology without ever needing to leave their desks. These technologies not only provide students with lessons in the science fields, but also help them develop social and emotional skills that are critical to success in higher education and the work field. The immersive

technology integrated in STEM motivates kids to employ their problem-solving abilities to find answers to impossible challenges and help to shape their future better. This paper is an attempt to analyze the impact of immersive technology in STEM education by providing advantages, challenges, and drawbacks of integrating this technology to an educational system. Additionally, the state of art papers in the filed of STEM learning using immersive technology are reviewed.

Full Paper VI

A Voice Assistant for IoT Cybersecurity

Jeffrey Chavis (Johns Hopkins University Applied Physics Laboratory, USA); Malcolm K Doster, Jr. (Charles Herbert Flowers High School, USA); Michelle S Feng (The Bryn Mawr School & Johns Hopkins University Applied Physics Laboratory, USA); Syeda J Zeeshan (Atholton High School, USA); Samantha Fu (Johns Hopkins University, USA); Elizabeth Aguirre (Johns Hopkins University); Antonio Davila (American University, USA); Kofi Nyarko (Morgan State University, USA); Aaron Kunz, Tracy Herriotts and Daniel P Syed (Johns Hopkins University Applied Physics Laboratory, USA); Lanier Watkins (Johns Hopkins University Information Security Institute, USA); Anna Buczak (Johns Hopkins University Applied Physics Laboratory, USA); Aviel Rubin (Johns Hopkins University, USA)

The Internet of Things (IoT) is becoming more pervasive in the home, office, hospital, and many other user facing environments (UFEs) as more devices are networked to improve functionality. However, this explosion of networked devices in UFEs necessitates that security systems become easier to help users remain aware of the security of the devices on their network. Users may not have the skills or the time needed to continuously monitor networks of increasing complexity using common open-source tools. Specifically, they are not likely to fully comprehend the data that those tools present, nor are they likely to have a working knowledge of the tools needed to monitor and protect their IoT-enabled network environments. This paper explores development of a system that uses ambient computing to facilitate network security monitoring and administration. Our system is designed to combine machine-learning-enriched device awareness and dynamic visualization of IoT networks with a natural language query interface enabled by voice assistants to greatly simplify the process of providing awareness of the security state of the network. The voice assistant integrates knowledge of

devices on the network to communicate status and concerns in a manner that is easily comprehensible. These capabilities will help to improve the security of UFEs while lowering the associated cognitive load on the users. This paper outlines continued work in progress toward building this capability as well as initial results on the efficacy of the system.

The Go-Light Game as a Tool for Enhancing the Mental Skills Required in STEM Learning

William R English, PE (LLLEI & DCPS, District of Columbia Public Schools, USA)

This paper presents the "Go-Light Game", as a tool to aid in the development and exercise of the mental and social skills required for students to succeed in STEM (Science, Technology, Engineering, and Mathematics) careers. Go is played primarily in Asia and said to be the oldest, most popular, and by far the most complex board game in the world. "Go is the ultimate mind sport. It has no equal in the strategic gaming world." (American Go Association, www.usgo.org). In addition, the Go Game context supports social skill development better than does playing video games.

To facilitate the use of the Go Game for the intended purpose, the game was scaled down from the full-sized 19 x 19 board with 361 stones to smaller, "Go-Light Game" boards of either 8 x 8 or 7 x 7 and a corresponding 64 or 49 stones. The Go-Light game play time, 15 to 30 minutes, is intended to be compatible with high school student schedules and interest spans. Unlike Chess, the Go Game can be scaled down in complexity under the same rules of play. Another adaptation to the high school context was to make the Go Light Game board and stones relatively inexpensive and portable.

Initial experiences with student Go Game play in diverse groups of Washington DC high school students are presented. Initial experiences demonstrate that the game has the power to attract, engage, and stimulate mental and social learning activity in a wide range of high school students in ways beneficial to STEM learning and career advancement. Confirmation of the general assertion, "the Go Game can be an especially useful tool in developing the mental capabilities to contain and apply STEM knowledge", requires further systematic play research and corresponding student cognitive performance testing.

How Do Students Learn Best? A Case Study of EGR244: Digital Logic Design

Golnoosh Kamali (Johns Hopkins University, USA)

As an educator, we are always asking ourselves how do students learn best? How can we keep our students engaged and help them comprehend the material? What can we do to increase student success? This preliminary study attempted to answer some of those questions. This learning outcomes assessment study tried to determine the most effective teaching method particularly for students in STEM by using data gathered from the EGR244: Digital Logic Design Class, taught in the Fall 2016 and Spring 2017 semesters at the Anne Arundel Community College in Arnold, MD. The methodology incorporated to determine the most effective teaching method was to map exam questions covering different chapters and the methods by which that information was taught with student grade outcomes. The two teaching methods explored were of a PowerPoint presentation lectures, whiteboard lectures, or a combinational approach. Results indicated that a combination teaching method of PowerPoint and whiteboard lectures were most effective in students learning the material and resulted in higher grade outcomes overall.

Performance of Modified LMS Control Algorithm for Smart Antennas

Salah Dauga (UD, USA)

Several adaptive filter structures are proposed for noise cancellation. This paper presents a modified least square algorithm(MLMS), the objective of this algorithm in this system is to use the filter weights w[i] for two algorithms, which are LMS, and Sign error algorithms. these use a modified LMS(MLMS) algorithm to adjust filter weights according to mean filter weights. Furthermore, simulation studies show that the MLMS algorithm gives better performance compared to LMS, and Sign error algorithms. Finally, the validity of this proposed algorithm is illustrated by three numerical examples. Index Terms-Adaptive algorithm, Adaptive filters, least mean squares algorithm, Sign error algorithm, modified least square algorithm.

In this paper, LMS algorithms are used by means of the ability of an adaptive antenna array with a number of elements for interference rejection. The effect on interference rejection of a wide range of factors in an antenna array is observed. As predicted from antenna theory, the predominant lobe and other lobe widths are reduced. The results of Simulation indicate LMS algorithms are efficient.

Use of Rubric and Assessment to Encourage Self-regulated Learning

Abrar Habib, Mona Ismail and Nuha Alzayani (University of Bahrain, Bahrain)

Self-regulated learning is the ability of a learner to consciously monitor and develop one's own learning independently. Some learners naturally exhibit this skill more than others. In an attempt to encourage self-regulation in learners, the assignments in a 400 level course for Civil Engineering undergraduate students are designed to replicate the main steps in a self-regulated learning cycle. The first step in the self-regulated learning cycle is setting the goals and perceiving the main features of the task. This step was implemented by asking students to evaluate a professional's work using a well-established rubric. The second step is for students to implement the task by themselves. The last step in the self-regulated learning cycle is self-reflection and self-evaluation. Each step involved students submitting an assignment (a formative assessment). In their reflections, students expressed positive attitudes towards this method and from their responses it was clear that helping them develop their meta-cognition improved their learning. Furthermore, it was evident from instructor observation while grading the assignments that the students made conscious efforts to reach the goals that they set at the beginning of the self-regulation learning cycle.

Works-In-Progress II

StartlearnING- an example for cross-domain learning arrangements combining engineering and biology

Markus Reiser, Martin Binder and Holger Weitzel (Weingarten University of Education, Germany)

The shortage of skilled workers in the so-called STEM professions demonstrates the urgency of introducing children and young people to technical and scientific topics at an early age. Following this approach, the project startlearnING offers learning arrangements that combine technical and scientific contents and promote the problem-solving competence of the students. StartlearnING uses design tasks as an interdisciplinary "bracket" and embeds the acquisition of scientific knowledge in a design process. To make the promotion of STEM teaching as effective as possible, the project acts on three levels: the students, the student teachers and the teachers.

The starting and finishing points are problems for which engineering solutions are developed. Biological phenomena are used as a source of ideas or concretize the requirements for the technical solution. In the learning arrangements, the

learners specify the problem, develop solution ideas and evaluation criteria, select promising approaches based on criteria, implement, test and optimize them. To do this, they must combine biological and technical expertise.
In order to familiarize teachers with the approach of designing according to the startlearnING principle, the project offers in-service training for teachers. In addition, the teachers are supported in their teaching by trained tutors.
The startlearnING project is also active in preparing prospective teachers in science teacher education and offers cooperative seminars in which student teachers and engineering students come together to contribute their skills and perspectives to problem-solving processes. They are trained and qualified in a problem-oriented design approach based on the startlearnING principle.
StartlearnING is scientifically accompanied by the Weingarten University of Education. Among other things, the impact of the learning arrangements on the motivation and biological expertise of the students is being investigated.

Which Definition Shall I Use? A Systematic Review of Computational Thinking Definitions

Fan Xu (The Ohio State University, USA); Shuhan Zhang (The University of Hong Kong, China)

Computational Thinking (CT) is considered a necessary 21st-century competence that should be introduced to school education as a vital ingredient. However, the lack of a consensus on the definition of this concept is still a big challenge for researchers and practitioners. In this study, we conducted a systematic review on the definitions of CT from the source of academic articles and classified the definitions based on 1) the approach for contextualizing the concept, 2) the purpose for defining the concept, and 3) the educational context where the concept was developed. Forty-five unique and original definitions were extracted from the search. Results indicate that 1) the existing definitions of CT were mostly formulated with a prototype approach, focusing on the essence of the notion; 2) The purpose for defining the term mostly stands on developing CT in the classroom and other educational settings; 3) K-12 education is the most common context for defining the term and computer science is the main background to enrich the CT concept. These results imply that there is a low necessity of putting forward new definitions, yet there is a need to build connections among current definitions and illustrate how to use them in appropriate situations. Also, the emergence of the definitions "Political Computational Thinking" indicates a broader application of CT, which implies a trend in future research of the use of CT in public, social and political fields.

Interdisciplinary STEM Undergraduate Programs and the Effectiveness of Computing Competencies within the Curriculum

Katherine Herbert (1 Normal Ave & Montclair State University, USA); Thomas J Marlowe (Seton Hall University, USA); Kees Leune and Robert M Siegfried (Adelphi University, USA); Jeanette Wilmanski (Saint Peter's University, USA)

Undergraduate interdisciplinary, multidisciplinary and transdisciplinary computing-related STEM programs are proliferating extensively. Each of these programs requires a robust computing component to be integrated into the curriculum. However, including an introductory, programming-oriented sequence designed for CS majors is not always the best fit for these multifaceted programs. In this work in progress paper, we set out to investigate possibilities and issues for the computing component, focusing on three fields: bioinformatics, data science, and cybersecurity. We explore commonalities and differences, and discuss initial plans to test our hypotheses. In doing so, we consider data organization, data acquisition, and a preliminary survey design.

Instill Autonomous Driving Technology into Undergraduates via Project-Based Learning

Weitian Wang and Laura Paulino (Montclair State University, USA)

Autonomous driving is seeing fast-growing development in recent years. In order to broaden the current generation's career pathways to this cutting-edge field, it is necessary to instill autonomous driving technology to our STEM students, who are not majoring in automotive engineering. This work-in-progress paper presents an underway new exploration to nurture undergraduate students with autonomous driving knowledge through a comprehensive hands-on program using the project-based learning pedagogy. Students in different groups will collaborate and exploit their problem-solving skills by developing a 1/10-scale autonomous vehicle on a scaled-down driving platform. The vehicle is configured with three main functions: pre-collision detection, lane tracking, and road sign recognition. Hardware and software systems of this autonomous vehicle are described in this paper. In the preliminary results, we present a developed vehicle that will be used to testify the functions of the hardware system and verify the feasibility of the proposed on-road applications. Future work of this project is also discussed.

Wide band gap using periodic combined electromagnetic band gap cells

Mohammad El Ghabzouri (Mohammed First University, Faculty of Sciences, Oujda, Morocco)

This work investigates the electromagnetic (EM) response toward two combinations of electromagnetic band gap (EBG) cells outlining our EBG structures under test. It has been talked about before that EBG structure identified as high impedance surface (HIS), act as background reflector as well as dropping EM wave surface, while the potential income of artificial magnetic conductor (AMC) is low profile devices. In this ongoing research paper, we used periodic combined cells, arranged in three manners (chessboard-like, intervallic-like, and mirror-like), in order to study the EM features of these original EBG structures. The motivation behind this work is to improve the band gap width (BGW) of our previous EBG circular slots meandered lines (EBG-CSML). The result shows a very interesting behavior of the mirror EBG-CSML structure, which manifests in ultra-wide BGW equal to 1.63 GHz, the realized fractional BGW is 66.5%. The presented EBG structures are designed for our project in progress that would integrate these EBG structures with antennas, in order to make a new competitive compact and low profile multiband antenna, with the lowest specific absorption rate possible, especially around mobile's lower bands working frequencies (700, 800, 900, and 1800 MHz).

Adaptive Tests using machine Learning for Math Tutorials: A Work in Progress

Julio Morales and Erick Petersen (Universidad Galileo, Guatemala); Oscar Rodas (Universidad Galileo & Tesla Lab, Guatemala)

The covid-19 contingency changed daily life as we knew it. These changes in education made to students and teachers engage in online classes that never do before. But that does not mean that every student could learn the contents or all the educators was able to teach properly. That is why some students could need personal tutors and these tutorials must have a validation of effectiveness and progress in student learning. In this work it is propose an adaptive model with machine learning, which will be in charge of proposing tests to adapt student's knowledge and reinforce the areas in which they need the most, using a question bank that is divided into 4 areas and levels of difficulty. Those test will help to demonstrate that the student is improving with the personal math tutorials, this could help them to be better prepared in STEM area and could make them choose a career in this subject at the university.

Saturday; March 13, 2021 1:30 - 3:00

K-12 Poster Presentation - Afternoon Session

Poster Session 2

Roy. G. Biv: The Color Matching Application for Artists With Limited Pigments

Nina M Borodin, Sylvan Martin and Ryan Sokolowsky (Reservoir High School, USA)

When looking at a finished art piece, it is hard to discern what pigments are used to create a particular color. To aid art conservationists and novice artists in color replication, we developed an application that takes in the RGB values of the desired color and calculates the pigment ratios necessary for replicating that color. From a survey of 139 respondents, a total of 86.3% wish that there was a product that would calculate pigments to mix for a specific color. The user interface of the application is familiar and intuitive; it contains a camera screen that averages the RGB values within a crosshair, a screen displaying the calculated pigment ratio, and a color library in which a color and its associated pigment ratio are saved. The application has a 97.8% RGB scanning repeatability, showing that the RGB input is nearly identical each time a color is scanned. To train a machine learning model, a database of 872 hand-painted acrylic entries was constructed using a limited palette. The final training RMSE for the boosted tree model was 0.036 and the final testing RMSE was 0.141. The median color difference in the pigment values between the replicated color and the original color was 0.0668. This shows that the mixed color is 93.32% similar to the desired color. The application not only successfully extracts RGB values from a scanned image to tell the user the necessary pigment values for recreating a color, but also is unique in its non-spectral approach to subtractive color mixing.

Covid-19 Case Prediction using Nesting Fitting

Bomin Wei (Princeton International School of Mathematics and Science, China)

In this study, we improved on the currently available models, logistic model for predicting the number of cases of Covid-19. The improved model, which we named Nesting Fitting, is a combination of common methods and models for fitting Covid-19 cases. The improvement was achieved by setting four free parameters in the Nesting Fitting model and then

fitting the parameters on Covid-19 case number in different regions. We observed the summed model prediction can closely fit the Covid-19 case numbers in short time, and the biggest difference came from the tail in long time. The performance of the model was measured by mean square error of the fitting, and the basic model equation is I(t)=a/(1+e^(-((t-b))/c))+d

We closely examined the deviation of our model prediction and Covid-19 data and realized a second breakout of Covid-19 cases in the data was one of the major reasons. To correct for this, we cut off the fitting at an empirical value, so the fitting would only include the last outbreak. Errors of this treatment was observed and found to be almost linearly correlated to the number of days in a short term. We fitted this error correlation with a linear function and removed its contribution from the model.

The performance of the Nesting Fitting Method on a temporal series dataset is much better than logistic and sliding windows methods, because this model considers more parameters such as region and secondary outbreak. We also compared the prediction of total confirmed cases of COVID-19 in the world with three other methods. The results showed that the prediction using the Nesting Fitting Method is precise and should be suitable for the region where a second outbreak has happened.

In the future, this research could be conducted in the following three aspects. To begin with, we need to explain the meaning of the fitting parameters in terms of case counts development. Furthermore, modification of the model is needed to include prediction of a second breakout. Last but not least, we could consider a more complicated model to first predict parameters from known regions fittings for prediction of case counts in a new region.

Identifying the Impacts of Digital Technologies on Labor Market: A Case Study in the Food Service Industry

Zeyi Ma (Beijing National Day School, China); Lufan Wang (Florida International University, USA)

Digital technologies like artificial intelligence, quantum computation, and 5G communication are advancing at an ever-increasing pace, which have tremendously increased the labor efficiency and workforce productivity. However, there is an increasing concern about the threat of technology innovation - will machines replace human jobs, and will digital technologies cause mass unemployment in the future? To better respond to the upcoming workforce transitions and formulate coping strategies for technological displacement, it is necessary to identify the impacts of such digital technologies on future labor markets and answer questions such as how job demands would change and how required workforce skills would shift. In previous studies, some scholars have quantified the impact of artificial intelligence (AI) on the whole labor market. However, they over-generalized their models and lacked in-depth analyses considering the unique characteristics of different industries. To address this knowledge gap, this research specifically focuses on the food service industry, and takes McDonald's as a case study. The research methodology includes three main steps: 1) data collection, which aims to collect McDonald's annual financial reports from 2006-2019; 2) data extraction, which aims to extract six financial factors from the annual reports (i.e., total revenue, total cost, operating income, number of employees worldwide, number of restaurants worldwide, as well as payroll and employee benefit cost); and 3) data analysis, which aims to analyze and characterize the trend of the extracted data. The results indicate that, with the wide use of digital technologies, company's operation efficiency has been significantly improved and the number of required employees per restaurant have reduced nearly 70% since 2007. This change could be due to the evolving technology at McDonald's, such as the Company's global mobile app, self-order kiosks, and AI-driven models such as the conversational ordering interface. The results of this research provides a better understanding of the impacts of digital technologies and trends of job demands in the food service industry. In our future work, we will further extend the case study to different regions and different types of restaurants to verify if similar trend exists in the food service industry in general. We will also develop regression models to forecast the job demand, and propose possible strategies to prepare for and adapt to the potential work displacements.

Wheeled Jumping all-terrain drones with Combustion-driven Semi-active Suspension

Leonard Yu (Princeton International School of Math and Science, USA)

Vehicle suspension is a shock-absorbing system of linkages and absorbers between the tire and the chassis. This research aims to implement active shock absorbers, which are pistons that could expand and contract under control, on four-track all-terrain drones using double-wishbone suspension systems of weight 1.0kg to achieve the jumping ability. Due to the fact that a large scale of thrust is needed for all-terrain drones to take off in a jump, two approaches were taken towards designing and constructing a capable active shock absorber. In the first approach, an electromagnetic shock absorber is calculated under computer models on Autodesk Inventor to be feasible of generating sufficient thrust by alternating its magnetic field under 280V voltage. Later, prototype tests suggested that the actual voltage requirement is approximately

400V to 440V, which is unobtainable on devices within the 1.0kg weight limit. Over-idealization of electromagnetic efficiency is mainly responsible for the deviation in voltage requirement. In the second approach, a special set of linkage is attached to the conventional suspension system of all-terrain drones to allow an expandable methane combustion chamber to provide thrust through expansion. After verifying its feasibility through multiple mathematical models, current work in this research focuses on reducing the stress corrosion on the attached linkage to allow repetitive attempts of jumping.

Analyzing Sex-Biased Gene Expression in Autoimmune Diseases

Vidyadhari Vedula (Princeton International School of Mathematics and Science, USA)

In this project, I plan to analyze sex-biased gene expression in autoimmune diseases by using a dataset containing information about people's cell counts. Autoimmune diseases happen when your immune system starts to attack its own healthy cells. No exact cause has been pinpointed, but some suspected causes are sex, race, genetics, and environmental factors. In terms of sex, autoimmune diseases are more prevalent in women than men. In all autoimmune disease cases, women make up 75% while men only make up 25%. Scientists have thought that this disparity could be due to hormonal factors. As we know, women have constantly fluctuating hormone levels, and this has been connected to autoimmune diseases. One study was performed to evaluate the effects of changing prolactin levels, a hormone that contributes to the production of milk in mammals. The study found mice with a prolactin-inhibitor had longer longevity and produced more antibodies that detect systemic lupus erythematosus (SLE), which is an autoimmune disease. On the other hand, mice with glands that produce more prolactin had accelerated mortality and proteins in their urine, which is a key symptom of SLE. For this project, I used R and RStudio, which is a programming language that allows me to analyze vast amounts of data. The database I used is called DICE which contains information about the donor's sex, race, ethnicity, and the count of various immune cells per 1 million transcripts. The data collection was done using RNA-Seq, which is a sequencing technique used to quantify RNA in a sample. In RStudio, the code I implemented followed a series of steps to build to a conclusion. To begin with, I eliminated data columns that aren't needed, after which I filtered the dataset into one with females and one with males. Next, I calculated the mean of each cell type for each divided dataset. Finally, I noted the differences in sexes by subtracting the male average from the female average for each cell type and calculating the absolute value of that difference. After this analysis, I found NK cells and Naive CD4+ T cells have the largest differences, each of which have been found to be abnormal in count or quality in people with autoimmune diseases. For future direction, I plan to narrow down on specific genes that contribute to the sex-disparity in autoimmune diseases.

Analysis and Construction of a Small International High School's Social Network

Daniella Reyes (Princeton International School of Mathematics and Science, USA)

Social network analyses have been conducted in school settings before, revealing to researchers the nature of students' habits and trends. In this study I, along with my research partner, will create a social network illustrating the relationships between 81 high school students of diverse backgrounds and ages. We'd be assembling said social network through the use of an email game in which students are told to send a message to their closest friends, as we track the spread of the message. In addition, a follow-up survey will be sent, having students self-identify their closest friends and who they spend the most time with. In doing so, a comprehensive social network will be made illustrating the friendships of students. As for results, we aim to observe the nature of relationships in the school, answering questions like: do freshmen often make friends with upperclassmen? Additional information like the ages, nationalities, and genders of the students will allow us to find out if certain characteristics are shared among friends. The results of this research will be beneficial when trying to understand just how tight-knit the 81 students are.

The Floating Compass: A Demonstration of Electromagnetism and Lenz's Law

Helena Rittenhouse (Princeton University EPICS, USA)

An electromagnet is formed when the magnetic field is produced by an electric current, usually running through a wire coil. The floating compass is an easy, visual explanation of this and Lenz's Law, formulated by Heinrich Lenz in 1833. Lenz's Law states that the direction of the current will always flow such that it is opposite of the change in magnetic flux, or the measurement of the total magnetic field passing through a given area. Lenz's Law is also oftentimes incorporated with Faraday's Law which allows the same coordinate system to be used for both the flux and the electromotive force (EMF). For this reason, it could also be used as an introduction to Faraday's law.

The Floating Compass contains a needle that has been magnetized, then poked through a straw so it floats in a tank of water. A coil of wire is partially submerged in the water so that the middle of the circle of the coil is where the water ends. This coil is then attached to a switch and D4 batteries set up in parallel, creating a circuit with a current running through

the coil, forming an electromagnet. Since the needle has been magnetized, it will then either go through the loop or be repelled. By flipping the switch the other way, the current's direction is flipped and the direction of the poles change, causing the needle to either do the opposite, demonstrating Lenz's law.
Having the magnetized needle floating on water stems from a discovery that Francois Arago made in 1822. He noticed that when the horizontal needle of a compass was suspended away from all foreign bodies, it settled at true north much faster than it did when it was not. This being true means that a needle floating in water, which is both away from foreign bodies which would affect oscillations necessary to settle and lacks surface friction and resistance, would come to rest much faster. For this reason, the needle in this experiment is floating (in water).
This project is very easy to replicate- all that is needed is a needle, a bar magnet, a straw, a container filled with water, some wire, D4 batteries, alligator clips, and battery holder packs (which are affordable/ often readily available). The demonstration is also easily comprehensible, makes it a great project for teachers to use in the classroom to teach the concept of electromagnetism, Lenz's Law, and maybe even the basics of Faraday's law. These are all important branches of physics, and this is an easy way to explain them to people of all ages.
The floating compass itself does not have many modern-day applications, though it can be fun to play with as well as demonstrating a concept that is very widely used. Electromagnetism is used in many electrical appliances to produce magnetic fields, including speakers, motors, generators, hard disks, MRI machines, and many more. Electromagnetism was discovered over 200 years ago and every year, people find new genius ways to utilize it.

Effects of Protein Concentration in Fish Feed on Physical and Chemical Water Pollution

Indeever Madireddy (BASIS Independent Silicon Valley, USA)

One of the seven characteristics of life is the ability to produce waste. Waste is the excess material an organism excretes after carrying out metabolic processes. Aquatic organisms like fish produce not only physical waste but also chemical wastes such as ammonia. Ammonia is excreted through fish gills and through their feces. In open aquatic environments, like oceans, rivers, and gulfs, this ammonia follows a nitrogenous pathway but is quickly eliminated from the system by plants, bacteria, and other microorganisms. In closed aquatic environments like aquaria and ornamental ponds, this ammonia also follows a nitrogenous pathway. As ammonia levels build-up from fish waste, a specific kind of bacteria called Nitrosomonas begins to grow. Nitrosomonas oxidizes this ammonia to produce nitrite. As nitrite levels build up, another bacteria called Nitrobacter begins to grow. Nitrobacter oxidizes this nitrite into nitrate. There is no bacteria in aquaria that can eliminate this nitrate, and thus, nitrate can only be removed by replacing the water. Ammonia and nitrite are incredibly toxic to aquatic life while nitrate is less toxic, but can get unhealthy at high concentrations. As long as ammonia is being produced, and the necessary bacteria are present, ammonia will be continually oxidized and nitrate will build up.

This research project determined three things. 1. How protein concentration in fish feed affected the build-up of nitrates 2. How protein concentration in fish feed affected the physical water clarity. 3. What concentration of protein ended up in the feces. Three different fish foods with a minimum protein concentration of 42%, 36%, and 28% were fed to three different species of fish: Pterophyllum Scalare (freshwater angelfish), Cyprinus rubrofuscus (Koi), and Carassius auratus (Tamasaba Goldfish). Each kind of food was fed to each species of fish for five days. At the end of this period, nitrate readings were taken to analyze the chemical pollution of the water.

To analyze the physical pollution of the water, the turbidity of the water was measured. To do this, a sample of fecal matter from each fish species from each type of food was diluted and mixed in water. After the feces settled out, the supernatant was analysed in a spectrophotometer.

To sum everything up, This research experiment determined how the protein concentration of fish food affected both the chemical (nitrate and protein) and physical pollution (turbidity) of aquaria and ponds.

An Exploration Into Electromagnetic Generation

Kritika R Ravichander (8 Sweetbriar Court, USA)

If we suddenly lost batteries one day, our lives would be changed completely. I personally feel so discouraged whenever my phone or laptop battery dies, which always seems to happen when I have something really important to do. Oftentimes, I'm not in a place where I can easily plug in my charger, which makes it even more difficult. My struggles, however, are nothing compared to my relatives in India who sometimes have to walk miles for an outlet, and frequently

run out of power in their house. I feel that exploring how to generate electricity with motion would help them through this by allowing them to simply push a button over and over, or pedal their legs in order to gain power.

Electricity and magnetism relate to each other, given that both the magnetic and electric fields depend on the movement of electrons. Changes in an electric field creates a magnetic field, and vise versa. This means that if you generate a magnetic field, then you will be able to generate current, which is known as induction. This is shown by Ampere's Law, or âˆ«B.dl = Î¼0I, where B = magnetic field, Î¼0 is the empty's permeability, and I is the path's enclosed electric current. It is also important to note Ohm's Law, or that voltage is the product of current and resistance. Since the strength of the magnetic field is directly related to the current in the wire, the magnitude of the magnetic field would increase with an increase in voltage in the circuit.

Attaching more magnets to an apparatus should increase the strength of the magnetic field, which should increase the amount of current. One can change factors such as the amount of magnets, and measure the products such as the amount of voltage. In order to produce a change in the magnetic field, one can attach the magnets to a spinning apparatus, such as a salad spinner, which would be above the electromagnet attached to a surface. That electromagnet would be attached to wires which would then be attached to a voltage meter to measure the voltage. It is important to keep the material and brand of magnets constant, as well as the electromagnet, materials used to set up the apparatus, and materials for the electric field.

Teachers in school would be able to make their own generator in the classroom using every day household objects. This would put into perspective how electricity is a part of objects around us. They can modify the apparatus as needed to show what factors affect electromagnetic fields and generation.

This project is exploring generators and electromagnetic fields on a small scale. This could be easily applied to a larger scale, including being able to power a house or a whole city. There is also flexibility with materials, meaning that new resources for generators can be explored.

Exposure to Navajo through Game Development: Guess the Number

KayDence N Low Dog (Navajo Preparatory School, USA); Jude J Thomas (Navajo, USA); Kritika R Ravichander (8 Sweetbriar Court, USA)

The Navajo culture, like many other indigenous cultures, is slowly dying, generation by generation. Many Navajo children are not exposed to their mother tongue, and are forced to turn to their grandparents if they want to learn their language. Cultural heritage is something to take pride in, yet it is slipping out of the hands of many indigenous tribes. In many cases, the generation of grandparents are the only ones with any cultural knowledge left, especially about the language. As they age, younger generations slowly have limited options, and many could only learn through school teachers on their reservations. Unfortunately, it is uncommon for indigenous languages to be taught in school, and fewer parents can make up for the lack of content in school. Many indigenous languages have become extinct, with others, like Navajo, on the verge of meeting the same fate.

Our game, Guess the Number, is designed and programmed in Unity, a game development program. The platform works together with C# script(s) so that a random number is generated, and users can enter numbers. The code compares the user input to the random number, and sends messages based on its comparisons. The platform has the capacity to be audiovisual, and both the numbers and messages can be in Navajo and/or English.

Teachers, especially those on reservations, can use this game to effectively expose and teach the Navajo language to students. Playing this game in math classes is also a fun and effective way to introduce the concept of integers being less than or greater than each other. The best time to learn a language is as a child, so it is important this game is incorporated in the elementary levels to increase access. An advantage of using this game in class is that there is little to no academic pressure in learning through a game, as opposed to traditional methods.

This introduces games that represent Navajo culture in a mainstream sense, while exposing children to number systems and counting in a multilingual way. The project also ensures the language is learned while playing through. It gives children examples to be inspired by when creating their own projects, as well.

Navajo Language Preservation AI

Nalanaya N Austin and Tymerah R Chischilly (Navajo Preparatory School, USA)

DinÃ© is a name which translates to "the people" in the Navajo language. In one way, "the people" has a strong meaning of independence, strength, and endurance. As a Southwestern Native American, our cultural language is of significant importance to us. This would be a normal assumption of all cultures being that our identity is vital in being a traditional person. Our language is critical because everything we know as a Navajo is passed down within our families. From one generation to the next, our teachings, stories, and practices were taught to us in our language.

The DinÃ© language is communicated orally. We would want to develop a game system in which to teach others the Navajo language. Our game would be introduced as an AI. What this system would do is create a conversation with another person using Navajo. This would help the user maintain a conversation in Navajo. It starts with the Navajo greeting, 'YÃ¡'Ã¡t'ÃÃ©h, _____', and have the user's name inserted. As the conversation prolongs, in between the user and AI, the more Navajo is used and less English will be used. The desired result would be for the user to have a complete conversation in Navajo.

A product made for the success of only the developer lacks when the audience is not addressed. In this case, teachers and students are the aimed users. Our game design is intended to teach. The game is formatted for easy use, accessibility, and straightforwardness. A classroom is the perfect setting for this. Teachers can use the AI for teaching students Navajo. Our AI is aiming to start in a simple conversation including both English and Navajo, and as progressing along, the AI will focus more on Navajo.

Forgotten language is common in Native American communities. People born in present times lack the fluency of speaking Navajo. It is not taught as often, not taught accurately enough, and is slowly disappearing. This game lays out the foundation of teaching Navajo virtually to others for those who would not have the resources otherwise to be taught. As from first person and third person views, the Navajo language is not the only language being neglected. We have Cherokee, Hopi, Crows, and many other respected tribes with their language being abandoned. This AI is a stepping stone in the revitalization of the Navajo language. This will also create a foundation for other tribes to do the same for their language.

Poster Session 3

Zoetrope Abstract by Anish Chaganti

Anish Chaganti (JP Stevens High School, USA)

Zoetrope Abstract
By: Anish Chaganti

The Zoetrope is a cylindrical shaped device that shows pre - picture animations which provide illusions to the human eye by showing a set of pictures moving as you progressively spin the device creating constant phases of motion. The device was originally named "Doedaleum" by an English mathematician named William George Horner in the 19th century and was modified throughout the years.

The Zoetrope device was so significant because it was the earliest form of recording animations and events through pictures before phones and cameras even existed. The Zoetrope is a spinning cylinder with slits cut vertically in the sides. There is a row of sequential images on the inside of the cylinder The user should look through the cuts and see the pictures move while the cylinder is moving.

It was the earliest form of 3D image available even before phones and cameras were invented where you can see pictures move through an illusion of motion. Cinematography is hugely influenced by the zoetrope due to the zoetrope's ability to create effects through motion presenting closely related images from one to another, paving its way to the future of CGI, graphics, and effects.

In our modern day classroom, teachers can use this to demonstrate rotation and motion to students. It's extremely user - friendly and gives an insight of how a zoetrope operates and how it influences modern day gadgets we use today on a daily basis. Students can see the origination of GIF, animations, and motion pictures and learn how rotation and motion works by testing the zoetrope. A practical demonstration will allow the students to gain a broader understanding of the

topic, understand how a zoetrope works, and figure out how to make one as well. The Zoetrope plays an important role when it comes to physics because a lot of explanations/theses of the theories are present in the device allowing the student to learn in an abstract way where they can benefit from, rather than traditional board and marker.

Zoetrope influence laid the foundation of a further improvised technology i.e Praxinoscope discovered in 1877. A Praxinoscope is a modified version of the Zoetrope but it included projection in it where moving images can now be portrayed on a screen . The fascinating part of the Praxinoscope was that it brought images to life without looking into a zoetrope to figure out what is going on. The images were visible to the naked eye and the audience would watch movies through a projector. Without the impact of the Zoetrope, the visual media would not have existed today and we wouldn't have seen the creativity outburst of modern day motion pictures. "Small things lead to big things which can possibly change the world in a matter of time."

Edison High School WiSTEM | FOCUS: Addressing Female Underrepresentation in STEM

Vasumathi Venkat (Edison High School & WiSTEM | FOCUS club, USA); Ishani Kunadharaju (Edison High School & WiSTEM | FOCUS club, USA)

Foundation:
STEM research has the potential to revolutionize a variety of fields, alleviating real-world problems on a global scale. Yet, half of the world's population seems to be excluded from input on the technology that is meant to change their lives. Women are chronically underrepresented in STEM fields due to gender stereotypes and a lack of self-confidence in a male-dominated sector (Ertl, Luttenberger, & Paechter, 2017).
Noticing this gender disparity within their own community, Edison High School STEM Academy juniors Vasumathi Venkat and Ishani Kunadharaju formed a club based on the principles of activism and passion for STEM. Mirroring the initiative at the Rutgers WiSTEM2D Conference, which featured the work and journeys of female professionals in the STEM fields, WiSTEM | FOCUS (Women-in-STEM | Female Opportunities Created Using STEM) was created.

Mission:
The purpose of this club is to empower girls through STEM. Our club hosts various projects that focus on allowing students, especially future women leaders in STEM, to find more opportunities in STEM fields. Additionally, we aim to introduce the mission and resources of the global WiSTEM (Women-in-STEM) movement to our local community.

Community Outreach:
This year, our club launched Project I3, an initiative in which our members host informative STEM-based seminars for middle schoolers. These mini-lessons aim to teach middle schoolers niche topics that are not covered in the school curriculum, including the COVID-19 vaccine, CRISPR Cas-9 technology, chemical crime-scene analysis, and lucid dreaming science. Currently, the presentations are being delivered through Zoom due to remote learning. However, more lab-based activities will be conducted as school returns to an in-person format. Throughout the year, our club will incorporate one-day activities, such as Scratch Night to teach coding to elementary schoolers and a STEM Trivia Bowl to encourage connections between middle and high school students. Together, these programs make STEM more accessible to students from a young age.

Developing Opportunities:
Simultaneously, our club runs projects to augment the skills of our own members. Some members participated in HackJA 2021, a virtual beginner-level hackathon. After this experience, our club plans to promote interest in computer science through Hackathon 101 sessions for aspiring coders. To motivate our members, we also host female Edison High School alum in STEM fields as guest speakers.
Additionally, our club will join several team-based competitions such as the Thomas Edison Pitch Contest and the iGEM competition. The goal of participating in these competitive activities is to help eliminate the stereotype that STEM and competition is designed only for males (Meyer, Cimpian, & Leslie, 2015).

Navajo Code Talker Game

Nathan A Henry (USA)

Historical Significance - The game is based on Navajo Code Talkers who were significant members of the marines during World War II. The use of the Navajo Language was instrumental in defeating the Japanese during the Second World War.

The Navajo Language is currently in threat of going extinct. According to the Navajo Times "In 1980, 93 percent of Navajos spoke the language. Ten years later, in 1990 it had declined to 84 percent. In 2000 the percentage of Navajo people who spoke Navajo was at 76 percent. Another decade later, in 2010, the Navajo language showed its most stark decline to date, to 51 percent." If these trends have continued into 2020, that number will have fallen to around 39 percent. And in 10 years it could mean only 20 percent

Project Description - This game seeks to emulate the Navajo Code talker language in an engaging battle type scenario. This game will preserve the Navajo Language and develop awareness of the historical contributions of the Navajo People. Game based loosely on Battleship combined with Navajo language. One team tries to gain points by coding with the Navajo Code Talker code and the other tries to stop them. This game teaches parts of the Navajo Language so that the players may gain an understanding of it.
The game is directed toward younger people who aren't that familiar with the Navajo Language. That way it may preserve the language by teaching it to a younger generation.
The future of this project could be to expand the game to include other indigenous languages that need preservation.

Sources
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Teaching the Navajo Language Through a Coded Game

Yilnazbah R Wauneka-Yellowhorse (414 Julie Dr & BlueCross BlueShield, USA); Jordyn Begay and Jaci Hood (Navajo Preparatory School, USA); Richard J Wegmann (USA); Alana E Smith (Navajo Preparatory School, USA)

Forty years ago, 93% of the Navajo population were fluent Navajo speakers. Presently, only 52% of the Navajo people can speak their native language. The Navajo language is slowly being forgotten due to the lack of education for Native American youth and a growing necessity to learn English for upward mobility.
To prevent the percentage of Navajo speakers from rapidly decreasing and possibly being forgotten within the next few decades, we've designed and coded a math puzzle which incorporates elements of Native American culture and Navajo language. The puzzle would help teach Navajo counting among not only Native American youth, but also others interested in learning the Navajo language.
This game can be used competitively in classrooms, as a fun, challenging family activity, or individually as a way to learn another language and see improvements within yourself. Our goal is to preserve the Navajo language within the Navajo Nation as well as extending the language to others outside the community.

The application of precision medicine for diabetes treatment

Ziqi Ma (Beijing Royal School, China)

Precision medicine has evolved from an initial focus on personalized medicine based on genetics to a broader notion that includes diagnosis, prediction, prevention, monitoring, treatment and prognostics by integrating multi-dimensional data from biological and extrinsic environments. It is beneficial to health problems, especially type II and gestational diabetes since both types are closely relevant to genetics and personal life habits. Our long-term goal is to continuously develop an app that monitors patients' real-time glucose fluctuations by using optical glucose sensors paired with a modified cell phone while tracking important information about individuals' unique biology, environment, and context to determine their potential risk factors. Helpful reminders are provided by integrating and analyzing individual data pool to minimize the exposure to specific risks. In this work, we use a proof-of-concept fluorescent glucose sensor implanted under a person's skin. The sensor's key mechanism is by applying the chemical equilibrium of Boronate formation between a Boronate Ester and Glucose to form a Glucose-Derived Bornite Ester. When alizarin-phenylboronic acid (fluorescent) binds with glucose, it will be dissociated into glucose-derived Boronate Ester (Not Fluorescent). Therefore, the change in fluorescence intensity corresponds to the glucose concentration. The modified cell phone measures the glucose levels by scanning the sensor spot, and fluorescence readout is then transmitted to our developed app. Furthermore, information such as weight, diet, excise and mental health are also recorded. With such information, the algorithm we developed in the app can interpret the personal data and finally generate a report that will be a significant reference in the precision diabetes therapy strategy. The app can also learn the user's lifestyle and provide some suggestions, such as the number of

calories in one meal and the type of exercise the people should do. Furthermore, we will have a social component in the app where users have opportunity to interact with their friends and followers to learn their healthy activities such as physical exercises. We believe that reminding people of paying attention to their health and guiding them to a healthy lifestyle will be the most meaningful goal of our work.

Franklin's Bells: Converting Electrical Energy Into Continuous Mechanical Motion

Stella C Firmenich (Engineering Projects In Community Service, Princeton University & Stuart Country Day School of the Sacred Heart, USA)

In a letter to his friend, Benjamin Franklin writes about an experiment he conducted, now called the Franklin's Bells. He writes, "In September 1752, I erected an iron rod to draw the lightning down into my house, in order to make some experiments on it, with two bells to give notice when the rod should be electrify'd." His setup was an adaptation of one made in 1742 by a German professor named Andrew Gordon. Franklin's Bells was an early demonstration of electrical charge and is one of the earliest examples of converting electrical energy into continuous mechanical motion. Franklin's setup consists of two metal vessels with a metal clapper hanging on a non-conductive line between the two. There is an electrical current connected to one vessel, and another is placed on a non-conductive surface.

How Franklin's Bells works is that when a positive charge is brought to one of the vessels, it attracts the negatively charged clapper. The clapper hits the vessel and then absorbs that charge and gets repelled. The now positively charged clapper gets attracted to the negatively charged vessel and the process repeats. It repeats until the charge has evened out again. The original Franklin's Bells used an electrical rod for the electrical current and the setup rang during thunderstorms. Occasionally it would ring without thunder, hinting at electrical charges in the air.

Franklin's Bells is also easily replicated using two aluminum cans, a soda tab, some string, a straw, a plastic lid, and an electrical source. The electrical source can be from rubbing a pvc pipe with wool or any other method to get static electricity. Place one aluminum can so it rests on top of the plastic lid and then place the other can about 1 Â½ inches away from it. Tie a soda tab to the end of the string. Take the string and tie it around the middle of the straw and balance the straw between the two cans so the tab rests between the cans. To get the tab moving, bring an electrical source near one can. For example, rub a pvc pipe with wool to collect static electricity and then bring the pipe to a can.

Teachers can use this demonstration in their classroom to show how electrical energy can be converted into a continuous mechanical energy. It is a fun experiment that is low cost, yet highly effective, and can easily be replicated by every student in the class.

I have been recreating this experiment and researching it for three months. The opportunity to do it was provided by a program run by Professor Littman at Princeton University called Engineering Projects In Community Service (EPICS). The purpose of EPICS is to recreate historical devices in electromagnetism and share these projects with the community by presenting them at local libraries, schools, and other events.

A Design of the Extrusion System for Chocolate 3D Printing

Hong Jiang (Princeton International School of Mathematics and Science, China)

Food 3D printing is one of the newest developments in food design and manufacturing with great potential in both food recipe and industrial processing. Chocolate 3D printing, especially, has received investment from big companies like Hersey and 3D System. Unlike the traditional production of customized food, which requires extensive skilled labor and a long process of molding, 3D printing food allows users to design the shape by editing the digital model file.

However, there are problems with the current chocolate printers that need to improve to make them popular. The first problem is that price is too high for individual users and small stores. Most people could not afford a printer that is about several thousand dollars, not to mention the expensive printer-specific material. Another problem is the ability of the printer. Some printers can only produce few default shapes set by the producer, so users do not have much freedom to print the shapes they want. This limits the ability that is supposed to be the biggest advantage of the 3D printer. And one of the biggest weaknesses of the current chocolate 3D printers is that they cannot perform tempering, a critical process in chocolate production. Without chocolate tempering, the final product chocolate will not have a smooth, glossy texture that is preferred for desserts. So the printer cannot be used for high-end dessert production.

The goal of this research is meant to design an extrusion system of the chocolate printer to solve these problems mentioned above. The goal of the printer is that it can take chocolate chips, temper the chocolate, extrude it out and form shape according to the design. It is designed to be constructed with cheap materials while having accurate control of

temperature during the printing process. This research is planned to last for two years long and now I am halfway through the first year. My current plan is to work on a commercial 3D printer and replace its extrusion system with my design. The general frame of the printer is kept because that is not the focus of this research. Right now, I have finished my design of the extruder in 3D models and start building and testing prototypes. In future research, I would expect to have the extrusion system assembled on the 3D printer and investigating the optimal working condition for chocolate printing.

Static Straw Spinner

Gabriel Saintil (The Pingry School Basking Ridge, USA); Hunter Jushchuk (Rutgers Preparatory, USA)

Static electricity was first discovered by Ewald Georg von Kleist, a German inventor. Static electricity is created by causing friction between two items. It can create a negative charge or a positive charge. These charges can attract each other if they are opposites and will repel each other if they are the same charges. When these charges come in contact with things like metal, which has a positive charge, you can get shocked.

How It works

When rubbed with wool the two straws end up with the same charges. When two objects have the same charge such as two positive charges or two negative charges they repel each other. This causes the straw you are holding to push the straw on the cup.

How teachers use this in the class room

This experiment shows static electricity in its simplest form, and how two of the same charges push against each other.

How this could be used in the future

Right now static electricity is used for electrostatic generators. Because movement is in a lot of things we do, static electricity could be something we use to power a lot of our items in our daily lives.

High School STEM Clubs In A Virtual World

Anastasia A Ibrahim (Edison High School & iSTEM Club, USA); Sunrit Panda (Edison High School & TEDxEdisonHighSchool, USA); Gunjan Adya (Edison High School & iSTEM Club, USA)

Transitioning To A Virtual School Year:

Edison High School's iSTEM Club faced numerous challenges in the summer leading up to the 2020-2021 school year. Club funding was cut due to school budget restructuring. All club recruitment events such as Freshman Orientation and the Club Fair had been canceled. Despite these challenges, club attendance increased during virtual meetings. This improvement can be attributed to changes in meeting style. Instead of appealing to students with opportunities and events, the officers used their large personalities to create a welcoming virtual community. Thus, the key to maintaining a virtual STEM club is energetic, personable meetings that keep students coming back for more.

Club Events:

iSTEM Club's officers looked to the virtual outreach events of universities as inspiration. Events were brainstormed with a focus on mental health, career development, community outreach. The iSTEM club continued to offer mentorship to students applying to summer programs in STEM research as this process only became more difficult virtually. Additionally, the iSTEM club taught the basics of HTML and web design in a three-part seminar series. These seminars doubled as training for teaching aides who will participate in future HTML workshops for elementary schoolers, engaging both elementary and high school students during remote learning. Finally, iSTEM club created a College, Career, and Mental Health seminar series addressing topics such as creating a resume, finding research opportunities, exploring career fields, self-care, time management, applying to college, etc.

These unique seminar topics allow club members to make use of free-time during online learning and further strengthens the welcoming community that attracts new members. For example, the HTML seminars may inspire a student to start a personal coding project. That student would then feel comfortable asking the officers for guidance. Furthermore, iSTEM Club officers decide which seminars to lead, developing valuable collaboration, public speaking and leadership skills.

Finally, the pandemic allows the time to plan for in-person events after widespread vaccination. ISTEM club plans to create an Apple Institutional Developer Account to teach Swift and publish apps to the App store. Most excitingly, the club

received a $4,250 grant from the IEEE-in-epics program to alleviate a water crisis in Rural India.

A Model For The Future:
Evidently, iSTEM Club has seen much success while adjusting to the online environment. This begs the question: Can high school STEM clubs go virtual or hybrid permanently? The evidence says yes. Savvy management of a virtual club yields lower costs, greater attendance, and a more impactful experience. Virtual seminars have greater reach and can be recorded for future use. Virtual community outreach teaches club members how to work efficiently and collaboratively in a virtual environment, an important skill moving forward. Finally, in-person events can be coordinated once safe to teach hands-on skills. Combining virtual community-building meetings and seminars with in-person skill-building events, iSTEM Club is a model for the high school club of the future.

TEDxEdisonHighSchool: A Template For Virtual TEDx Conferences

Sunrit Panda, Neoma A Chowdhury and Aditi Deshmukh (Edison High School & TEDxEdisonHighSchool, USA)
Going Beyond The TEDx Guidelines:
TEDx talks are brief and powerful. Limited to eighteen minutes, these talks are a concise glimpse into the speaker's background and topic. Adding to the rigorous TEDx speaker guidelines (TED Conferences LLC), the TEDxEdisonHighSchool curation teams have devised three techniques for curating TEDx talks in a virtual world.

Number one: the throughline is a pithy, memorable statement that encapsulates the point of the talk. In particular, Amy Cuddy's and Melissa Marshall's TED talks inspired this idea (Marshall, 2012, Cuddy 2012). The impactful throughline stimulates attendees' interest, especially as 'Zoom fatigue' reduces attention span for virtual events.

Number two: a three-meeting curation timeline allows for the efficient curation of high-quality talks. This small time commitment appeals to busy professionals and academics who have limited time for speaking appointments. Employing this timeline, three independent curation teams have planned and executed an eighteen-speaker TEDxEdisonHighSchool conference in only two months, with a three hour per week time commitment.

Number three: collaborative technology such as Google Documents, Calendly, and Miro facilitates efficient, on-time meetings. Calendly allows multiple teams to centrally schedule speaker meetings. Finally, a series of templates streamlines the speaker invitation and talk outlining process.

Taking Advantage Of The Virtual Climate:
Hosting a virtual TEDx conference lowers costs and expands reach. Normally, TEDx conferences are immense ordeals involving caterers, venues, stage designers, sponsors, and more (TED Conferences LLC). Additionally, TEDx limits most organizers to one conference in a twelve-month period with a maximum of one hundred attendees. However, a virtual conference only requires an online meeting platform and allows for multiple conferences in a single twelve-month period without the one hundred attendee limit. For example, in addition to the one conference per year afforded by a TEDx license, TEDCountdown and TEDWomen allowed TEDx licensees to host their own offshoot conferences. Finally, there are no geographic limits to speakers.

Next, the Zoom video conferencing service allows for further enhancements of TEDx events. Zoom is unique in having one of the most seamless, high-quality screen sharing features. Hence, live speakers can be supplemented by showing pre-recorded talks on the TED website. Furthermore, small-group discussions, called TEDxCircles, can be incorporated through Zoom breakout rooms. These allow for intimate conversations that delve deeper into the speakers' background and topic. Finally, Zoom's attendee limits can be bypassed by streaming live to Facebook or Youtube, further increasing the event's reach.

Impact On Online Learning:
A virtual TEDx conference addresses the need for "diversity in [a student's] learning experience" (Gillett-Swan, 2017). TEDx talks break up the monotony of lectures with its unique, fast-paced structure. And, by involving features such as TEDxCircles small-group discussions, students can learn soft skills such as public speaking, and networking. For example, the TEDxEdisonHighSchool Countdown conference shone a new light on climate change. Speakers from the NJ Sierra Club

and Columbia University discussed novel viewpoints such as climate change youth outreach. When combined with online classes and assignments, TEDx conferences can enrich the learning experience for an otherwise isolated student.

Enhancing Chess Engine with a Personalized Quantitative Database

Jiasen Liu (Princeton International School of Math and Science, China)

Designing chess engines have become a popular topic of computer science studying since 1997, when Deep Blue, invented by the IBM company, defeat Gary Kasparov in a 6-game match. Nowadays, chess engine designers improve their engines with more efficient neural networks, enhanced self-learning methods, complete databases of past games, and so on. However, what these designers ignore is the human's perspective of playing chess. Different human players have different styles and preferences, and even when their Elo ratings are near, they may choose various options in the same situation. This human's way of thinking is what modern chess engines do not consider, and I assume that their performance when playing against human players could improve by considering these different styles. What this research is attempting is to set up a personalized quantitative system based on previous games. The author's and some other chess players' understanding of chess would be added to create more enhanced standards for this quantitative system. After that, the system will be implemented to Stockfish, the best open-source chess engine in the world, by modifying its source codes. If the modified engine knows the opponents they are facing, it adds those quantitative statistics into analysis with a specific weight. Instead of directly calculates the best moves for a position, the engine chooses the moves that bring the hugest challenge for the opponent, and the moves chosen vary when the opponents change. Then, the performance of Stockfish will be compared to its original version, and verify whether the engine gets better. If the research is done successfully, both the designs of the chess engine and the methods for training human players would get improved.

Saturday; March 13, 2021 3:00 – 5:00

Paper Presentation - Evening Session

Works-In-Progress III

Entrepreneurship Education in Engineering Using Key Performance Indicators

Frank Washko (Saint Martin's University, USA); William Edwards (Kettering University, USA); Leslie Washko (Saint Martin's University, USA)

Engineering entrepreneurship education tends to focus on management and subjective skills rather than unique business models. A business idea itself does not dictate how a company will be managed or if a business will survive beyond the startup stage. And, ideas and management can never be separated from one another when it comes to entrepreneurship. However, the objective qualities of a proposed business model can be a predictor of the success of a startup. A critical concept to teach engineers is Key Performance Indicators (KPI's) that are present in successful business models that entrepreneurs can leverage at the early stages to give their startups an edge. This research identifies at least seven such KPI's.

Virtual Computer Engineering Summer Camp Experience in the Era of COVID-19 Pandemic

Girma Tewolde (Kettering University, USA)

This paper presents the experience of the author from a virtual computer engineering summer camp in the era of the COVID-19 Pandemic. The target audience for this pre-college summer camp was high school students. Even though the university had a long history of offering on-campus day and residential summer camp programs in several areas, the camp that was offered in the summer of 2020 was the first of its kind for being offered completely in virtual mode. To keep the participants engaged in the program, the camp material was designed to include a great deal of hands on activities involving electronics, microcontrollers, sensors, and robotic kits, as well as programming. This paper presents the structure of the program, description of the content delivered, and reports on results of the survey completed by the participants to assess the effectiveness of the program. Based on the survey results we conclude that the program turned out to be successful with 92.3% of the survey respondents reporting that the virtual camp has satisfied their initial expectations and 100% of them reporting that they would recommend the camp to others.

Supporting Inclusive Engineering Education using Global Virtual Teams

Anuli Ndubuisi and James Slotta (University of Toronto, Canada)

Future engineers require global competencies to help them transition to the labor market in an increasingly complex, digitized, and evolving world economy. In response, an International Virtual Engineering Student Teams' (InVEST) program was developed, in which multidisciplinary students were engaged in collaborative technical projects within a global virtual team learning environment. This study examines engineering students' intercultural competencies and supports their development of those competencies within the context of a global engineering project where they work in culturally diverse teams. We report on two successive iterations of the engineering global virtual team (GVT) learning program. Each included a pre-survey to understand student's initial knowledge and cultural orientation and a post-survey to assess students' perceptions of their intercultural learning and experiences. We found that blending global virtual team learning with collaborative international projects was an effective strategy for helping engineering students gain international exposure in an inclusive manner while developing intercultural competencies, virtual team collaboration skills, and technical engineering knowledge.

Fine-grained Analysis of Gender Bias in Student Evaluations

Eric Dillon, Haroon Malik and David Dampier (Marshall University, USA); Fatma Outay (Zayed University, United Arab Emirates)

The most widely applied tool to evaluate the teacher/instructor performance in a course is by collecting numerical responses against a set of questionnaires, about the instructor and the course, along with comments in free-form text. Published research results depict biases in student evaluations of instructors in ratings, as well as in comments. However, the research so far has not been directed at the fine-grained analysis of gender bias -- opinion (sentiments) of students towards qualitative metrics of their interaction with the instructors. The work-in-progress (WIP) proposes (a) a methodology to mine teaching evaluation and (b) an open-source tool to facilitate educational establishments execute empirical studies and students perform exploratory analytics on the teaching evaluations.

Expanding Access to Microscopy

Aaban A Syed (Johns Hopkins University Applied Physics Laboratory ASPIRE Intern & North County High School, USA); Imaad Syed and Lafe Spietz (JHU APL, USA); Aric Sanders (NIST, USA)

State-of-the-art microscopes cost thousands of dollars, posing challenges to third world hospitals and secondary schools. Additionally, there is a growing problem of "e-Waste", where consumers throw away old pieces of technology to buy newer models. The rare, valuable, and hazardous materials used in those technological devices pollute the environment when thrown in landfills, and could cause harmful effects on human, plant, and animal health. The overall goal of this project was to up-cycle old computer parts to make a cheap, open source microscope to address these issues. Optical drives are designed to be very precise, in order to "read" data from very small spaces on CDs/DVDs. There is an objective lens to change the angle of the laser, and a very precise stepper motor to slowly change the position of the laser assembly to read different parts of the CD/DVD. These principles were applied to modern microscopy in order to construct a microscope for a couple hundred dollars, as opposed to thousands. Such a prototype is being constructed, and samples will be placed to view magnified images to test the viability of the microscope. After completion, all instructions and software will be uploaded to GitHub for cloning and open use. This will allow for greater access to microscopy for students and for those in developing countries.

Saturday; March 13, 2021 3:00 - 5:00

K-12 Poster Presentation - Evening Session

Poster Session 4

Using hashing to improve efficiency in cross-image duplicate detection in research publications

Tongyu Lu (Princeton International School of Mathematics and Science, China)

BACKGROUND

Cases of research misconduct had increasingly exhibited themselves through the duplicate figures that they contain; Bik et

al. [1] examined over 20 thousand biomedical published papers and found that 3.8% had inappropriate duplicate figures, with this percentage on the rise in recent years.
Currently, the identification of figure duplicates is mainly carried out by human reviewers; the process is slow and requires specialized training. There have been attempts to develop large-scale screening tools for image duplicates, but they are either unpublished [2] or do not perform very well.

METHODS

There exists prior research in the field of copy-move forgery detection. These deal with duplicate regions on a single image, but the methods could be modified and applied to cross-image matching, as we intend to. However, cross-image matching implies a much larger feature set to match between, and feature matching is currently the slowest step in the process [3].
Currently, there are two directions to address this problem. One is to use keypoint-based features, such as SIFT, to decrease the size of the feature set. The other is to apply hashing to the features and use hash lookup to quickly eliminate those features that definitely don't match; Bayram et al. [4] demonstrates that using bloom filters in place of traditional methods increased the matching speed at some loss of result accuracy.

We plan to devise a method that applies hashing to matching SIFT features in order to reliably perform faster than prior methods on cross-image matching in large biomedical image sets. We expect the resulting method to perform faster than current methods with little to no loss of accuracy.

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Golden Ratio Lettuce

Bela Sameep Sanghavi (1312 Ashton Falls Drive & O'Fallon Township High School, USA)

The golden ratio is a mathematical concept seen in all aspects nature. From petals of a flower to a shell of a snail to even human finger anatomy, the gold ratio is used. The golden ratio is É¸ = (1+âˆš5)/2 which is approximately 1.61803398875. This equation derives from the Fibonacci sequence which adds the last two numbers to form the third, such as 0+1=1, 1+1=2, 1+2=3, and so on. When the two addends are put into a fraction, with the larger number as the numerator, as the sequence goes higher, it becomes closer to the golden ratio.
Over a 2-week time span, this experiment will show how using the golden ratio of peat moss to soil will affect lettuce growth. In the experiment, 1 part peat moss and 1.6 parts soil will be mixed in a pot, producing the "golden ratio soil". Another pot will contain 1 part peat moss and 1 part soil. The plants will be daily monitored for any growth.

Interactive At-Home Learning

Anishi R Desai (William Fremd Highschool & None, USA)

Through the times we are all apart of together, everyone has had to make changes in their daily cycle. With the situation that comes with several outcomes, education takes charge as the most prevalent result. The ways students learn is very different than what it was a few months ago and adapting to certain measures some may not feel comfortable endorsing into. The main factor is the roles that teachers play; they have to find ways to keep their education both interesting and impactful. In my math class, the days seem to blend as we only go through the same cycle every day. Since some kids, including myself, learn better when the topic is interactive and also competitive, I want to propose the idea of having a game near the time of a quiz or a test to make the review process more fun and interactive. It will increase the amount of participation in the class and the students will feel more comfortable asking questions.

Fun of Physics

Kayla Desai (Fremd, USA)

Throughout the integration of the new education system, teachers and students have been doing their best to teach the content with the same level of "fun" they would have in an actual, in person class. A class that I have seen this happen in was my Physics class. Everyone has seen the wonders of physics class whether it be in person or online. There are so many things that the class physically shows to help better the students and their understanding of the topic. Near the end of December of last year, my teacher had us make a Rube Goldberg project that had to complete a certain task without any human intervention. My poster will show different examples of Rube Goldberg and how my project was reflective of that. There will also be an explanation of the project, going step by step of what happened specifically to better show the function of the project, to show how there was no intervention, how it worked, and how it better showed our understanding of the topic that we were learning. We were also instructed to integrate the project with the things we learned and I feel that without the the introduction of the project, myself and the group that I had worked with wouldn't understand the concept of the topic that we were learning and finishing

Consumer Barriers For The Adoption Of Climate Friendly Packaging In Mercer County

Inara D Jain (Princeton High School, USA)

In early November of 2020, New Jersey passed legislation banning single-use paper and plastic bags to take effect in May of 2022. As of February 2021, restaurants and grocery stores seem to show slow initiative to adopt more climate-conscious packaging options. This could be due to hardships on businesses due to the pandemic or the perception of unrecoverable packaging costs. This proposal entails collecting Mercer County consumer preferences on the adoption of climate-friendly options and assessing how much value consumers put on these options. This data can be shared with businesses in Mercer County to catalyze these businesses to adopt climate-conscious packaging options. Data will be collected through primary research done via electronic anonymous survey tools promoted via social media channels. Secondary data sources relating to Mercer County will also be evaluated.

Application for Individualized Learning Using Artifical Intelligence

Anant Gupta (Great Neck South Middle School, USA)

This pandemic has forced us to abandon the normality of our lives. My mother is continuously buying stuff from Amazon.com and my father is always checking his stock portfolio while I have got stuck in tiring zoom sessions. With this remote methodology, learning has lost its luster. The person-to-person relationship with teachers is not the same, and what is left is a shell of what I was used to. Other sources including Brilliant, CK-12, and Khan Academy also lack individualized learning like the one I found in a brick-and-mortar school. So I thought about building a tool to impart knowledge based on the skill level of each student. I want to make an application (app) powered by artificial intelligence (AI) that will closely monitor the student's past performance and response time and will provide him/her with personalized content. I learn best in a question and answer (Q&A) format, so I plan to create an app to deliver rich scientific content to students in a Q&A format. It will also have an administrative interface where teachers worldwide can add questions and videos explaining the answers. I envision it to be a great teaching tool for the less advanced countries and students with limited resources, who cannot afford private tutors. As Google's CEO Sundar Pichai says, "AI is one of the most important things humanity is working on. The newborn will have to learn continuously over their lives. So, we have to transform how we do education."

- Anant Gupta

Smart Education Supply Preparedness

Adrik Ray (Huber Street Elementary School, USA)

Education is evolving with remote online education coming to the forefront during the Covid-19 pandemic. This has also driven students to be more self-driven and prepared without the classroom help, they would have received from teachers. In this paper, we discuss how modern technologies like Internet of Things (IoT) sensors, smart intelligent speakers enabled with fast wireless connections like 5G, can enable students to be better prepared for their classes without unnecessarily worrying about their preparedness every day.

We have lots of things to remember for school in addition to our studies. Every day, we have to remember to check our school supplies. If we forget, we may have to scramble for our school supplies or to get them ready for use during classes. The supplies may also be out of place for various other reasons. Sometimes parents, siblings or friends borrow our supplies and forget to return. Sometimes we go on a vacation and the night before school, we realize our supplies are not in place. We may have to put reminders for this repetitive and mundane task to check our supplies every day.

The above problem made me think that there got to be some way in today's day and age to take care of this repetitive but important task in a smarter way. I have contemplated a design consisting of a smart organized supply box which will store different types of supplies with slots designated for same. The box will provide personalization options with inputs such as age and other optional configurations about the user of the box, making it usable for students of different ages. The intelligent box will use IoT visual sensors placed inside with adequate lighting, to capture images of supplies. The sensors interface with a circuit, that takes inputs from the sensors and detects scenarios like inadequate shape of items (blunt pencil, broken pencil etc.), lack of items (missing erasers, specific colors etc.), misplaced items etc. Once detected, the circuit passes appropriate programmed commands to connected voice control devices like Amazon Alexa, Google Home, Apple Siri etc. These devices would take the commands and send voice alerts and/or send alerts on the smart phones for the students or parents to replenish and/or ready specific supply items, if needed. Additionally, the box can generate insights for parents to monitor and analyze consumption habits of the students over time; and the degree to which they are organized in their daily lives. This will enable parents to work with the students to achieve the habits, lifestyle and goals they desire. Finally, automating these regular tasks will improve productivity, save time and make our school life much easier and efficient - after all, time is something the smart people say, cannot be bought with money.

Some of the changes in our lives necessitated by the Covid-19 pandemic will have lasting impacts. Living our daily lives smartly and efficiently for a better school-life balance certainly will be one of them, and my paper contributes to this goal.

Lego Robot for Guiding the Blind

Rishi Balaji (Gates Elementary School, USA)

One kind of health problem that exists today is blindness. There are ways to communicate with blind people such as braille. There are also ways to help them in their predicament such as using guide dogs or having another person help them with certain things. The robot I made was based on guide dogs, a type of dog which guides a blind person and helps them go to different places. It uses an infrared sensor to detect walls and other obstacles, then guides the blind person around, giving them directions by saying certain things like saying "Turn left" to inform the blind person that they should turn left, saying "Turn right" so the blind person knows to turn right, and saying "Object detected" to warn them that the robot has detected an obstacle. I used LEGO Mindstorms EV3 to build my robot. Compared to a normal guide dog, there are a few pros and cons to this robot:

Pros:
- It does not need to be fed food constantly
- There is no need to take it to the vet

Cons:
- Its sources of power such as batteries might need to be changed constantly depending on how much it gets used every day

Fibonacci Lemonade

Arden Upadya (Morristown Beard School, USA)

In my project, I will show the densities of lemon juice and simple syrup by making lemonade using the idea of the Fibonacci Sequence. I will use the concept of the Fibonacci Sequence to create different layers with simple syrup and lemon juice as the ingredients. The materials I will use for this experiment are a teaspoon, a tablespoon, a drinking glass, ice, food coloring, simple syrup, lemon juice, a spoon, a bowl, and a towel for the mess. The Fibonacci Sequence was founded by Leonardo Pisano who was an Italian mathematician. The sequence is created by adding the two numbers before it to get a new number and it goes on to infinity. A few numbers in the sequence are 1, 1, 2, 3, 5â€¦. For example, I will use one teaspoon of lemon juice in the first layer, one teaspoon of simple syrup in the second layer, one teaspoon of each in the third layer, and so on going by the Fibonacci Sequence. The amount of teaspoons for all of the layers will go like this: 1, 1, 2, 3, 5, 8, 13 and this will create the different layers of liquid. I will put the amount of simple syrup in a bowl and then put the amount of lemon juice in the bowl. Next, I will put two tablespoons of water, one drop of a certain food coloring, and then mix the ingredients. Then, I will use a spoon to help me take the mixture from the bowl, and put it into the drinking cup. I am planning on doing a certain color, and then on top of it, there will be a clear layer since I don't want the liquids to merge at all. In the end, from bottom to top, it should look like: blue, clear layer, green, clear layer, yellow, clear layer, and finally red. There will be ice in the cup filled all the way to the top as well. Students in a class setting can use this experiment and have fun learning about density and the Fibonacci Sequence. This is a fun way to learn since you get to drink the results! Also, it is a safe, visual hands-on activity, and some students learn better from visual lessons. Compared to the normal lesson, I think that students will be engaged and learn more. Students can make their own lemonade and learn why the colors are separated and not mixing together using science. All in all, I think that this experiment is an interesting, cost friendly, STEM project that will be highly effective and exciting for students in a classroom.

Design and Testing of Solar Power Heating

Victor I Robila (Hunter College High School, USA)

The use of non-renewable energy sources continues to impact the society's ability to minimize its environmental footprint and impedes the efforts to slow down climate change with stark implications to the global economy, humanity's own well-being and even existence. The importance of this topic is illustrated by the constant presence in the news as well as support for broad efforts to identify and perfect alternative sources of energy. The use of renewable energy sources, such as water, wind, or solar continues to grow, however challenges in efficient energy production and storage remain. The sun's emanated energy constitutes one of the most readily and widely available renewable resources. Yet, converting it to usable energy still requires expensive equipment such as solar panels. This poster investigates the design of solar heating of liquids as a means for improving the energy transfer. While solar water heaters have been used for decades, improvements in design have not kept up. Various aspects, such as the heater design and coating as well as the addition of salt to the water were considered as part of the experiments for this project. In my work, I posed the hypothesis that heating salty water is more efficient than regular water because the salt would make it harder for the heat to escape. The solar heater followed a classic box design with the liquid circulating through a transparent tube inside the box and connected with a container in a closed loop system. As it heated, the liquid would travel upwards through the tube towards the container. When the water travelled into the box, it would heat up and rise outside of the box. Experiments that controlled both the light intensity and other environmental parameters (such as outside temperature) showed that the use of salt in water results in speeding up the heating process. The experiment showed, not only that the heater was successful, but also that adding a saline quality to the water would in fact make the water heat up faster and be more practical. This could be immensely practical in use at a larger size and while the increase may seem small, this could be a big part in helping eliminate the use of fossil fuels in at least one of the many sectors involving them.

A Review of the Relationship Between Diabetes and Diabetic Amputations in the United States: An Expensive, Chronic but Preventable Condition

Gabrielle Rose Kiewe (Schechter School of Long Island, USA); Hugh Herr (MIT-Harvard, USA); Francesca B Riccio-Ackerman, Aaron Jaeger and Daniel Levine (Massachusetts Institute of Technology, USA)

The number of people living with diabetes is expected to increase to 250 million worldwide by 2025. Diabetes is a chronic condition that requires constant care. Not everyone has the financial means to upkeep their diabetic care. When diabetes becomes unmanageable, it often causes unknown infections, or ulcers, which can lead to the need for amputation. This increase in type 2 diabetes largely contributes to the near doubling of the current amputated population in the U.S. As of

2004, 68 percent of major amputations were due to diabetes. This is especially an issue because people with diabetic amputations not only have to deal with an amputation, but also with a chronic illness that they have difficulties managing. Most studies look into the cost of surgery and prosthetics, which is easily tens of thousands of dollars. However, previously completed studies have not looked into the indirect costs and productivity losses, which excludes the costs on the family and society as a whole. Diabetes contributes to $237 billion in annual costs, which makes it the most expensive chronic disease in the U.S. So much so, that one in every four dollars spent on healthcare goes toward diabetes. Without understanding the complete cost of illness, that money can not be spent effectively to help those with diabetic amputations.

Since the cost and time commitment of maintenance for diabetes is very expensive, there's a natural relationship between low socioeconomic areas and high rates of untreated or undertreated diabetes. Consequently, these areas also face high rates of diabetic amputations; studies show that certain low-income neighborhoods have 10 times higher amputation rates compared to their high-income counterparts, as a result of lower resources, medical infrastructure, financial support, which are important factors in diabetes management and living with an amputation. Racial disparities are another factor of amputation. Black Americans are under-represented in treatments that would prevent or delay preventable limb loss and over-represented in amputation surgeries. Both economic and racial disparities together create centers of extremely high amputation rates, which is shown by geographic clustering of diabetes and amputation rates. Diabetic amputation is considered one of the most preventable chronic conditions. Studies have shown that 75 percent of diabetic amputations could have been prevented through education, earlier identification, and treatment of ulcers. Experts suggest more than 80,000 toe, foot, and lower-limb amputations could have been prevented with better diabetic control.

As the prevalence of diabetes grows, it is important to document and better understand rates of diabetic amputations, how they come about, and best practices for preventing them. Most studies providing data regarding diabetic amputations are outdated and need to be updated regularly to inform policy-makers how to allocate resources for prevention. Thus, areas of work that specifically need to be highlighted are amputation prevention and health equity.

Poster Session 5

Photophone Re-invented

Roshan S Natarajan (Whittle School and Studios, USA)

The photophone, invented by Alexander Graham Bell in 1880, is a telecommunication device that allows transmission through a beam of light. A photophone uses light waves to transmit sound. There are two parts of a photophone, the receiver and the transmitter. The transmitter receives the sunlight. The receiver then receives the reflected sunlight and turns the light wave into an audio wave via an amplifier. Bell describes the photophone:

"We have found that the simplest form of apparatus for producing the effect consists of a plane mirror of flexible material against the back of which the speaker's voice is directed. Under the action of the voice the mirror becomes alternately convex and concave and thus alternately scatters and condenses the light."

In this quote Bell is describing the transmitter which is a mirror that is reflecting the sunlight to the receiver which is narrowed through a dark tube and onto a solar panel. This solar panel is then connected to an amplifier which then converts the light waves to the sound waves ultimately producing the sound that is played behind the mirror.

Materials:

Audio Amplifier	22 AWG Wire	Rubber Band
Solar Module	9V Battery	Plastic Water Bottle
0.1µF Capacitor	Electrical Tape	Cardboard
Speaker	Aluminum Foil	

Method:

Put together (or buy) an audio amplifier that will be used to convert the light beams into sound waves.
Attach the speaker to the audio amplifier.
Place the capacitor on the positive terminal of the amplifier which will connect to the positive side of the solar module.

Create a tube out of cardboard or some other material. Then tape on the solar modules to the end of the tube(make sure that there is no sunlight present in the tube).
Create a transmitter by using a reflective object that will direct the sunlight towards the cardboard tube(receiver).
Then attach a speaker or another mode of audio to the back of the reflective object (these sound waves will then be carried on a light beam and transmitted to the receiver).
Adjust the transmitter until the sunlight is reflected down the tube and is transmitted to the receiver.

Future Applications:

The photophone uses light waves to transmit sound over a certain area and time. This can be applied on a large scale. A future application can be an intergalactic photophone in which a person can transmit light waves across our solar system and be able to communicate with people back on earth. This can be tested on the ISS as well as on the moon and if there is ever a colony on mars this would be a fast way of communication. It would be an intergalactic photophone.

The Science Behind Flappy Bird

Steven S Santos (Johns Hopkins Applied Physics Lab, USA)
Mobile games have become immensely popular over the past decade, due to the widespread adoption of smartphones. Over the years, many games have come into the spotlight due to their addicting and fun nature. Flappy Bird was one of the most popular games in the world around its release, played by millions of users all around the world. The game was released in 2013, but was removed by the creator due to guilt over the widespread addiction. Due to its popularity there have been hundreds of copies released on the internet that are still popular due to the popularity of the original game.

Flappy Bird is a mobile game originally developed by Dong Nguyen, a Vietnamese videogame programmer. Flappy Bird is a side scrolling game, like the popular game Super Mario Brothers, where the player controls a bird in a 2D environment. Unlike Mario, the player only has control over the bird's vertical movement. The main goal is for the bird to travel as far as it can without hitting any green pipes. While the goal and controls are simple the game becomes increasingly difficult and frantic as the bird moves faster the farther it travels.

Python is a computer programming language used for many software applications and can be used to create video games on the internet when paired with tools such as Python Arcade. Flappy Bird is one of the games that can be created using Python, and when coded correctly the game can be an almost perfect version of Flappy Bird. During the coding process we created a game design plan with two to three week intervals for our Flappy Bird project. The beginning stages involved establishing a solid plan, sectioning off code, and setting up a skeleton by putting down basic coding. The later stages involved adding on to the skeleton by putting more advanced code down, adding secondary items such as sprites, coloring, and lighting, and adding the finishing touches to the game.
We were able to fully recreate Flappy Bird in python as well as add a few of our own ideas to the game by following our game design plan. While we were able to find the original game's assets, we had to identify most of the original logic by visually watching the game being played, which was more difficult than expected. For our original ideas, we added a second chance feature that allows players to continue after dying if they solve a special challenge. A video will be made available of our recreation of Flappy Bird during the poster presentation and the code will be available on GitHub.

Exploring ethics in IoT-based smart cities
Michelle S Feng (The Bryn Mawr School & Johns Hopkins University Applied Physics Laboratory, USA); Jeffrey Chavis (Johns Hopkins University Applied Physics Laboratory, USA)
As a result of the ever-growing demand for progress in technology, the concept of the smart city has erupted as a method of integrating electronics into governance. With the potential of futuristic systems and advancements that the smart city presents, it is important to maintain awareness of how smart technology may differ in its effects on worldwide communities. In improving their respective cities, big data and human-focused technologies in governance must address all ethical concerns. The consideration of the socioeconomic, racial, and other factors is necessary for all stages of the smart city process-data collection, interpretation, analysis, and the eventual implementation of data-based decisions. However, the idea of "right" and "wrong" shifts depending on historical context. This poster will define some measures of ethics in the artificial intelligence of smart cities and compare how specific cities meet the overall guidelines. Each city's Internet of Things usage in addressing environmental concerns, city infrastructure, and citizen satisfaction will be weighed

against factors of community involvement, risk management, and transparency. The latter list of items helps adapt a city's systems to the needs and beliefs of their people (i.e., cultural context).

The Math Behind Piano Chords

Zuko A Ranganathan (Hart Magnet School, Stamford CT, USA)

In this poster, I shall describe the mathematics behind piano chords. Both major and minor chords are formed by three keys or notes, and both follow the rule of 7. In a major chord, we follow a 4 + 3 rule, where we pick the root note, and then 4 keys higher and then 3 keys further up. In a minor chord, we follow a 3 + 4 rule, where we pick the root note, and then 3 keys higher and then 4 keys further up. Just a small change in the middle key results in a big change in the mood of the chord (happy vs scary or sad). There are several variations of these formulas when we have chords with inversions. I shall explore the math behind this mood change and explain other mathematical formulae behind piano chords.

IoT & Smart Cities: "Smartainability"

Malcolm K Doster, Jr. (Charles Herbert Flowers High School, USA); Jeffrey Chavis (Johns Hopkins University Applied Physics Laboratory, USA)

A smart city is an urban area that uses different types of electronic methods and sensors to collect data. Insights gained from that data are used to manage assets, resources and services efficiently; in return, that data is used to improve the operations across the city. A concept known as Smartainability is a method for assessing the sustainability of a smart city and IoT applications. Without a sound way to assess smart cities functionality, establishing them would be more challenging. The Smart City paradigm aims to improve citizens quality of life in a scenario where the percentage of people living in urban areas is getting higher and higher. The Smartainability approach allows researchers to estimate, with qualitative and quantitative indicators, how smart cities are more sustainable (and smart) in environmental, economical, energetic and social fields, thanks to innovative technologies.As for results, multiple dimensions, KPI (key performance indicators), and quantifications were recorded and analyzed from the case study in charts. This Smartainability development is focused on two aspects; The first aspect is the methodology consolidation and the definition of guidelines to replicate the assessment, the second one is the extension of Smartainability analysis from the Expo site to real city cases. Using this collected data to implement on real city cases could be the next step to establishing functional, interconnected smart cities.

The Fibonacci Sequence and The Golden Ratio in Math and Music

Nicole E Vassilev (Princeton High School, USA)

The exact origin of the Fibonacci sequence is unknown. However, it is widely recognized to have first been used by Leonardo of Pisa, an Italian mathematician, to solve a breeding issue with rabbits. It has since evolved into a complex system that has been used and taught for many centuries. Whether we realize it or not, Fibonacci numbers and related ideas can be found in almost everything in our lives.

A Fibonacci sequence consists of a list of numbers beginning with 0 and 1, in which each number is the sum of the two previous numbers in the sequence. For example, 0, 1, 1, 2, 3, 5 are the first numbers in the Fibonacci sequence, because 0+1=1, 1+1=2, 1+2=3, and 2+3=5. This pattern applies to any number in a Fibonacci sequence. The ratio of two fibonacci numbers that are one next to each other will always be extremely close to 1.618, the "golden ratio." 1.618 is also known as "phi'' which originates from the 21st letter in the Greek alphabet Î¦. My research will look into the application of the Fibonacci sequence and the golden ratio in music specifically. On a foundational level, the Fibonacci sequence can be observed within a scale. The 5th note in a scale is the most important, and it happens to be the 8th note in an octave, which consists of 13 notes. Upon the division of 8 by 13, the rounded result is 0.615, a number practically identical to the golden ratio. It's important to note that 5, 8, and 13 are all also numbers in the Fibonacci sequence. Beyond this foundational level, the Fibonacci sequence and golden ratio play a more widespread role in the composition of large musical works, such as in the first movement of a piece by Hungarian composer BÃ©la BartÃ³k. His piece, Music For Strings, Percussions and Celesta, is divided into two parts. Part one has 55 measures, and part two has 34 measures. When those numbers are divided, you get 1.6176, which when rounded, is 1.618 (the golden ratio). The Fibonacci sequence also makes appearances in rhythm, such as in the complex Konnakol rhythm by B.C Manjunath, which uses the first eight numbers of the Fibonacci sequence as its basis. My research will explore these occurrences of the Fibonacci sequence and the golden ratio in musical construction in order to more clearly demonstrate the parallels between music and math.

Sensitivity of Voter Turnouts in Presidential Elections - A Retrospective Analysis

Kavin S Sankar (Enloe High School, USA)

Voter turnout is a major swaying factor in presidential elections. One of the main missions of presidential campaigns is to rile up their political base and independents to come to the voting booths and vote for them. An important comparison is the 2016 and 2020 elections. In the 2016 election, the democrats (Clinton) won the popular vote but the republicans (Trump) managed to win more key states and won the Electoral College, and the presidency. However, in 2020, the democrats energized were smarter about campaigning and put lots of effort in increasing voter turnout in key swing states. In fact, the republicans voter turnout in 2020 increased by 17.84% in relation to 2016, but democrats increased their voter turnout by 23.43%, which allowed the democrats to win the presidency. This indicates understanding sensitivity of voter turnouts and how it affects the Electoral College is an integral part to predicting which candidate will win the presidential election. There are many minor and major factors that can significantly alter voter turnout for both parties. The objective of this research project is to understand what affects voter turnout and by how much it affects the outcome in key battleground states.

Towards this, I have analyzed the 2016 election in R to understand which states had the closest elections. My analysis of percentage difference between the 2 parties' votes at national scale shows the strategies by both parties at the county level. The republicans campaigned for the more rural areas and won many more counties than the democrats in key battleground states. On the contrary, the democrats campaigned primarily in urban and populous areas, thereby winning the popular vote but not the Electoral College. Another big factor behind the republicans' win was that the republicans won most of the battleground states (Michigan, Florida, and North Carolina) by a close margin. All of these states had the closest margins in 2016 with Michigan being the closest state that year. Out of the top 10 closest state electoral colleges the republicans won 6 of them (102 electoral colleges) and the democrats only won 4 of them (23 electoral colleges). This analysis shows how important it is to focus campaigning in key counties relevant to their base and also sway independents towards their candidates.

I intend on continuing this analysis of voter sensitivity by going through all of the elections in the 2000s. I plan to develop an analysis interface which can take user inputs to analyze the past elections. These user inputs can be a list of past close state Electoral College outcomes or it can be a change in voter turnout indicated by percentage increase/decrease towards a party in key battleground states. I also intend to analyze correlation patterns between voter turnouts and key socio-economic indicators (e.g., employment, economy and crisis). This way we can analyze the change of the close battleground states and use recent events to determine what is having the biggest impact on voter sensitivity.

(Mentor: Dr. Brian Reich, Dept. of Statistics)

Smart City Overview

Syeda J Zeeshan (Atholton High School, USA); Jeffrey Chavis (Johns Hopkins University Applied Physics Laboratory, USA)

This poster outlines what are Smart Cities and why should we integrate these smart city applications into our communities. This work delves into the general benefits of smart technology and their integration into smart cities. I will describe what a normal life would be without the influence of technological advancements in smart cities and then show how smart cites and IOT technology will benefit various aspects of society. As most of the world becomes increasingly technology dependent, corporations and governments will need to collaborate to assess financing for a new wave of smart applications, IoT devices, and artificial intelligence that will shape everyday life. I explore how this may be realized.

Diagnosing Skin Cancer Using Artificial Intelligence and Machine Learning

Riya J. Roy (Ridge High School, USA)

Artificial Intelligence (AI) and Machine Learning (ML) have many applications in the healthcare field. A life-saving way in which these futuristic tools can be used is to diagnose skin cancer. I developed AI & ML models that can diagnose 7 different forms of skin cancer just from a skin lesion image. My goal was to enable people to upload an image of their skin lesion, and the model will generate a diagnosis for them and a percentage for the diagnosis' accuracy. Thus, anyone can quickly and easily receive a precise diagnosis.

I first researched about skin cancer and found that 1 in 3 cancers are skin cancers, indicating its prevalence. In certain communities, access to professional healthcare is scarce, depriving patients of quality care. To alleviate this, I created a website using AI & ML where people upload a picture of a skin lesion and obtain a diagnosis. Since people upload their own pictures, I had to consider that these images are likely not professional images, but the model should still diagnose it.

Hence, I performed data augmentation on my dataset of skin lesion images. I made duplicates of my dataset and manipulated them by flipping, blurring, resizing, or zooming them using OpenCV.

I then created numerous machine learning models such as K Nearest Neighbors (KNN), Convolutional Neural Network (CNN), Grid Search CNN, and Transfer Learning, to determine which model best diagnoses the different skin cancers. I evaluated the models using the Receiver Operator Curve (ROC), which shows the relationship between a model's true positive and true negative rate. To interpret the curve, I used the Area Under the Curve (AUC) metric, which compares the model to one which randomly guesses. Additionally, I plotted Confusion Matrices to view a detailed configuration of each model's performance. After evaluating, I found that my Transfer Model performed the best. For my Transfer Learning model, I used Keras' VGG16 Machine Learning model as the base, and added my own layers of neurons to it. I further improved this model by considering different skin tones, since a bias in the dataset and model can be dangerous to those who use it. Thus, I trained my model on images of multiple skin tones. I then deployed this model to a website I created using JavaScript and HTML.

My design allows people to visit my website, upload an image of their skin lesion, and receive a diagnosis in seconds. My design met my goal of creating a model which could output a diagnosis based off of just a skin lesion image. I also created a user-friendly website that makes the process of receiving a diagnosis easy and efficient.

Going forward, I want to improve my Transfer Learning model as well as explore additional machine learning models. This way I can improve the diagnostic accuracy of my model. This is crucial as a false diagnosis in the medical field can be detrimental. By continuously improving my project, I hope to help those who struggle with skin cancer.

Filtere - Filtering water using a variety of efficient filtration methods

John Tewolde (Grand Blanc Community Schools, USA); Joshua Tewolde (Grand Bland West Middle School, USA); Girma Tewolde (Kettering University, USA)

This project is about the design of a low-cost water filtration system. I started this project after I realized how many people got sick or died from drinking contaminated water. When I thought about this, I took to mind how many people I could impact using one invention. Filtere is important to people who do not have access to clean drinking water, because clean water is essential to human life. An important feature about Filtere is that it can be used on any type of container of water because of the places I decided to put the technology I used in. Filtere can impact 2 billion people through its potential!

The problem I solved was the lack of clean drinking water. This is a major world problem that needs to have a solution quickly or the result will be catastrophic. My goal was to engineer an advanced water filter that could remove all bacteria and germs in water.

I solved my problem of making contaminated water drinkable by creating my portable, interchangeable, affordable water filter. My filter is made to fit on top of a water bottle, so that the filter acts as a middleman between the faucet and the bottle, so that it filters the water as it goes through the bottle. You can then take Filtere off the top of the bottle easily for later use. I also kept in mind that the filter would have to be small but effective so that it could fit inside the bottle while filtering water completely. My criteria were as follows: to remove up to 99.99% of bacteria and other harmful particles, to be small and portable for everyday use, to be inexpensive for wide distribution efforts, and to be watertight on behalf of the electronics.

My invention demonstrates the importance of STEM. I used science to learn how to remove bacteria from drinking water. I used technology in the creation of Filtere when I looked at different systems such as GAC (Granular Activated Carbon), Ion Exchange, UV lights, and looking at how they could be implemented in Filtere. I used engineering in Filtere by prototyping different designs of Filtere and analyzing the pros and cons of the designs. I applied math when I created Filtere by doing calculations on the pricing and size of Filtere.
After extensive research, I developed two prototype designs. The major difference between the two is in the number of filters. The first prototype included only one UV light filter. On the other hand, my second design included three filters (GAC, Ion Exchange, and UV light). I chose the second design to meet my filtration criteria. Hence, Filtere can remove much more germs and particles than otherwise possible.

Using Technology as a Means for Musical Outreach to Nursing Home Residents

Joshua Tewolde (Grand Bland West Middle School, USA); John Tewolde (Grand Blanc Community Schools, USA); Girma Tewolde (Kettering University, USA)

On March 15th, 2020, the coronavirus was declared a pandemic by the WHO. This marked the beginning of the disease which wreaked havoc on our social and economic livelihoods, and continues to do so today. However, the pandemic hasn't hit everyone equally. Unsettlingly, it is our most vulnerable population -- the elderly -- that are most at risk. As of today, nearly 40% of Covid-19 deaths have occurred in Nursing Homes, while they amount to less than 6% of our population. Unfortunately, that is not the only epidemic sweeping our nursing homes. Loneliness, Alzheimer's, and Dementia are rampant as many live for an extended period of time away from loved ones.

In the spring, as my brother and I were isolated at home, our school held a contest in conjunction with the Positivity Project to exemplify character traits in the community by pursuing a project of choice. Our goal for this project was to partner with nursing homes so that we could play music for the seniors and frontline workers over Zoom. At last, on a warm April afternoon, I logged on to Zoom as my brother stood over my shoulder. Over the following summer months and into the fall, we did more than 2 dozen live musical meetups to diverse audiences. In fact, we got so much demand that we ended up releasing a YouTube video in addition to the live streams because of increased demand for the music and social experience, and the video ended up getting nearly 700 views in a matter of months. From Mainers to Texans to Alaskans and Hawaiians, we had the opportunity to perform for frontline workers in nursing homes and our seniors across the States, playing genres from classical to jazz to soothing church hymns.

The presence of music alone can help wonders, not to mention the live human interaction associated with our project. Music can do a very special thing to stimulate the brain. Music first enters through the ears in the form of sound waves, which vibrate after striking the eardrum. After a series of steps, the vibrations reach the cochlea (the key hearing organ), which is filled with a fluid that reacts to the vibrations. As the fluid moves in accordance with the music, thousands of cells translate the fluid's movement to electrical currents, and send the currents to the auditory cortex in the temporal lobe of the brain. At that point, information goes out to different parts of the brain, stimulating different areas for different components of music. This cross-brain stimulation is crucial in combating mental conditions such as Alzheimer's or dementia. This is an issue of utmost importance, especially now, when thousands more seniors have died of mental conditions due to the isolation brought by the pandemic.

Note: To evaluate the effectiveness of our outreach, we conducted a preliminary survey and found that we garnered an average of 9.3 on a scale of 10 for level of satisfaction.

Poster Session 6

Automated Classification and Conceptualizing 3D Shape, Texture, and Pose of Wildlife in Camera Trap Imagery for Enhanced Conservation Efforts

Thomas Y Chen (Academy for Mathematics, Science, and Engineering, USA)

Wildlife across the planet have been ravaged by numerous devastating factors, including climate change, deforestation, hunting, and pollution, leading to many taxa being classified as threatened, endangered, and critically endangered. As more species disappear, the loss of biodiversity contributes to not only the decline of ecosystems but also adverse impacts on human livelihoods, income, local migration, food sources, medicine, and health outcomes. To combat this troubling trend and provide resources for species' conservation, wildlife biologists must have access to accurate and efficient computational tools to detect, classify, and assess individuals and populations. Camera traps have emerged as a widely utilized technology to capture images of wildlife at all times of day, allowing scientists to study them without disruption to their daily activities. Because large quantities of data are necessary for deep learning, many datasets have been published, each containing different combinations of species categories. The Labeled Information Library of Alexandria: Biology and Conservation (Lila BC) is an open data repository housing many such datasets, including "Great Zebra and Giraffe Count," "Whale Shark," "BIRDSAI," "Amur Tiger Re-identification in the Wild," etc. Baseline models have been trained on these datasets (with code in publicly released Github repositories) and data is downloadable. While conventional methods required scientists to manually peruse the thousands of images produced, recent deep learning approaches have allowed for rapid, accurate classification and assessment. Furthermore, there have been recent

advances in the unsupervised translation of objects in 2D images to 3D representations including shape and texture. In this proposal, I propose the combination of these two techniques into one project to classify animals in a diverse camera trap imagery dataset and subsequently create 3D models of them, for the purpose of enhanced knowledge about trends within endangered populations. I have started this project as an independent research endeavor. I am a student researcher with extensive experience in machine learning research that works with researchers at MIT and the Qatar Computing Research Institute (QCRI) on other projects, including for assessing damage in objects in imagery using computer vision. I have previously presented research at machine learning/AI conferences like NeurIPS and AAAI workshops.

Impact of Black Lives Matter Movement on the LGBTQ Movement in Other Countries: A Comparative Study

Hyunwoo Kwon (Rise Research Group, USA); Andrew Kyung (NVRHS, USA)

The growing momentum of the Black Lives Matter Movement in the United States has raised awareness of global discrimination against minority groups. Black Americans have endured decades of implicit, systemic racism despite the equal protection mandated by the 14th Amendment of the U.S. Constitution. Egregious discrimination is reflected not only in police brutality toward Black men and even women but also in the disparity in health care treatment for people within the Black community as reflected in relatively higher mortality rates.
Similarly, the LGBTQ community has encountered discrimination and harassment in other countries for decades. Despite the country's adoption of UN Resolutions and local laws to provide them equal treatment and protection in recent years, conservative groups within this traditional society are resistant to granting too much liberal protection for these sexual minorities. While the respective rights of the Black Americans and LGBTQ overseas are seemingly relatable, a closer analysis reveals a cultural distinction which creates a greater obstacle for the LGBTQ movement in other countries.

Eddy Current Pendulum Brake

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

My poster for the 2021 IEEE STEM Education Conference is a demonstration on Eddy currents at work and how they are applied throughout the world. On the poster, there will be diagrams of how Eddy currents work, the history of Eddy currents, and Eddy currents used in technology today. Eddy currents work by nonmagnetic, but conductive metals such as copper and aluminum resisting movement in a magnetic field, or vice versa. As an example, the experiment that I shall present is a copper disc pendulum that passes a pair of magnets. When the copper disc passes the magnets it is a conductor going through a stationary magnetic field, which means that Lenz's law, which states that the direction of the electric current which is induced in a conductor by a changing magnetic field is such that the magnetic field created by the induced current opposes the initial changing magnetic field, applies. So when our pendulum passes the magnets, an opposite force to the pendulums momentum is applied, decreasing its speed by a massive margin. Eddy currents were first observed in 1824 by FranÃ§ois Arago when he noticed rotary magnetism in conductive metals. LÃ©on Focault is credited with the discovery of Eddy currents in September, 1855 when he observed increased force being needed to rotate a copper disc between magnets. Today, Eddy currents are used as frictionless brakes in countless roller coasters and was the brake of the Japanese Shinkansen until the N700 series, which used regenerative braking instead. Eddy currents are also used in dynamometers to control loads placed on an engine during sessions.

Utilizing Computer Vision for Natural Disaster Relief Efforts from Satellite Imagery

Thomas Y Chen (Academy for Mathematics, Science, and Engineering, USA)

Climate change threatens ecosystems and human civilization across the globe. Particularly, one of its most devastating effects is the increased frequency and intensity of natural disasters, including extreme weather events like floods, hurricanes, and tornadoes. Inevitably, the increase in these devastating events causes the loss of human lives, the destruction of structures and property, and overall economic loss. Therefore, we present a deep learning methodology building off of previous work that examines which input modalities are most useful for training convolutional neural networks for post-disaster damage assessment, as well as loss-functions and other model specifications. This project was completed with the mentorship of Ethan Weber, of MIT. I am currently working with his lab to conduct further research on damage assessment in imagery using deep learning-based computer vision. Natural disasters devastating countless communities every single year. From hurricanes to tornadoes to earthquakes to floods, these events cause the loss of human lives and properties. Additionally, they cause building damage that reflects the severity of the disaster in the different areas that were stricken. Therefore, in order to allocate resources in a timely manner after these disasters so that a swift recovery can progress, there must be computational mechanisms to accurately and efficiently assess the levels of damage to buildings caused. We can do this through machine learning, using satellite imagery as our source of

data. By training convolutional neural networks on training data consisting of concatenated pairs of images that were taken pre- and post-disaster, respectively, we can create technologies that predict how damaged buildings were. We do exactly that, and also focus on the aspect of interpretability of the models (the level to which humans can understand the inner decision-making processes of the machine learning algorithms). This is especially important when keeping in mind the end users of this research, which are primarily in disaster-prone and remote areas. We train nine convolutional networks with different input modalities, including the pre-disaster image, post-disaster image, and disaster type, as well as different loss functions, including cross-entropy loss, ordinal cross-entropy loss, and mean squared error, and compare the accuracy results.

Study on the Time-scale Separation in Communities Networks with Consensus Dynamics

Amanda Kyung and Andrew Kyung (NVRHS, USA)

In this paper, dynamics, time-scales and communities were studied using graph theory. Simulations were performed by writing a code to simulate consensus dynamics on a network, and verify that the dynamics asymptotically converges towards a constant state. Adjacency matrix (unweighted) of a structured network with random groups was discussed in this research to study the consensus dynamics on this network which displays a time-scale separation.

The presented code showed a plot of the vector set and x(t) and they converged to the average value after sufficient time steps.
In contrast to the normal patterns, a greater time-scale separation was observed. This was because there were many less edges connecting the different communities: intuitively meaning the communities have less of an effect on each other, or that to have an effect it will take much more time. Increasing the number of random edges between communities- i.e. the magnitude of the perturbation to the adjacency matrix of the three separate communities-will reduce the time-scale separation, making it so that the communities reach the same consensus value at a certain time.

Results show that until around t = 0:05, approximate consensus is reached within each group, then a consensus is reached between the groups.

The Use of Optimization and Derivatives in Calculus to Create More Sustainable Food Packaging

Kyle Mayers (The Lawrenceville School, USA)

This project seeks to reduce consumption of packaging materials for chip bags by using Calculus. The gaol of this project is to inform manufacturers of their capabilities to create more sustainable packaging while relieving the burden of consumers to be unrealistically sustainable. The poster will cover the process by which optimization and derivatives are used to create the perfect chip bag; this bag will also have the perfect ratio of empty space to chips so that the product stays fresh and tastes good. by displaying the calculus process used to determine the dimensions of the bag, both consumers and manufacturers can walk away knowing how calculus is tied to sustainability.

Study on the Metal Organic Frameworks(MOFs) for the Treatment of Pancreatic Cancer

Amanda Kyung (NVRHS, USA)

Due to increased surface area, porosity, and functionality, Metal-organic-frameworks (MOFs) have the potential to be effective in cancer diagnosis and treatment. Generally, nano-therapeutics offer considerable promise in this area as they show higher tumor uptake, increased efficacy and reduced toxicity compared to their molecule counterparts. To that end, MOFs are used within PCT-affected tissue to transport electrons to and from the reactive oxygen species (ROS) which are the primary cause of cell death.
In this project, various nano-scaled drug agents that enhance medical imaging of anatomic boundaries for better examination and diagnosis of anomalies in the body, such as dementia and cancer(theranostic), are studied using computational and theoretical analysis. As a part of the research process, MOFs with various combinations of functional groups are modeled using molecular editing software to measure optimization energies which are recorded to determine the relative stabilities of the molecules. Molecular editing programs with diverse features that determine the biochemical and physical values of the structure's properties are used to model the MOFs.
Ultimately, it is observed that the pore environment produced by functional groups on MOF clearly influences the enthalpies in the nMTV-MOF-5 series. Members of a new class of chemically and thermally stable MOFs based on Zirconium (Zr IV) and Niobium(Bb IV) show progressively better performance. Through the aforementioned program, Density Functional Theory (DFT), a computational and quantum chemistry, is used in order to model the electron properties of the MOFs compounds for pancreatic cancer therapy. This takes the form of various force field options, which

are a set of equations to optimally place atoms and calculate energies. Within the context of this program, it is a set of equations under the name UFF.

Classification of Skin Phenotype: Melanoma Skin Cancer

Ayushi Kumar (Monroe Township High School, Monroe Township, NJ, USA); Ari Kapelyan (Bergen County Academies, Hackensack, NJ, USA); Avimanyou K Vatsa (Fairleigh Dickinson University, Teaneck, USA)

Skin cancer (skin phenotype) is most common cancer in United State of America (USA). Skin cancer can affect anyone, regardless of skin color, race, gender, and age. The characteristics of skin phenotype of melanoma lesion has an arbitrary shape, size, uneven and rough edge, and cannot be divided in half. Further, it is a leading cause of deaths worldwide. Every year, more than 5 million patients are newly diagnosed in USA. The deadliest and serious form of skin cancer is called melanoma.

The diagnosis of melanoma has been done by visual examination and manual techniques by skilled doctors. It is time consuming process and highly prone to error. The skin images captured by dermoscopy eliminates the surface reflection of skin and gives better visualization of deeper levels of skin. In spite of these, image of skin lesion has many artifacts, noises, complex nature of lesion structure. Due to these complex natures of images, the border detection, feature extraction, and classification process is a complex problem. In order to identify and predict melanoma in early stage, there is need to classify images using better classification and prediction algorithms.

Therefore, there is need to make an efficient, effective, and accurate melanoma identification, classification, and prediction such that it may be identified and classified in very early stage. The goal of this poster is to review and analyze the various classification deep learning algorithms - Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN) - on images of skin lesions on each one of those and test with publicly available International Skin Imaging Collaboration (ISIC) archive large data sets. Also, ISIC raw datasets will be preprocessed and resized to make the data compatible to algorithms. Moreover, the performance of these algorithms will be measures and compared using five parameters including ROC.

Understanding Complex Malware

Daniel Edis (1Bergen County Technical High School, Teterboro, NJ, USA); Taylor Hayman (Fairleigh Dickinson University, Teaneck, NJ, USA); Avimanyou K Vatsa (Fairleigh Dickinson University, Teaneck, USA)

With the surge of cybercrime and contribution of malware (malicious software) attacks in cybercrime, there is need to design a smart and deep engine-based Intrusion Detection Systems (IDS). The malware could be virous, worm, trojan, etc. and their behaviors are dynamic and static in nature. IDS may monitor events and activity of malware and classify them in order that prediction of potential attacks can be made for users' sensitive data and associated computational resources. Moreover, the false positive rate alarming of IDS systems is high. Therefore, there is need to reconsider the design of IDS systems, increase its detection accuracy, and elevate prediction of vulnerable attacks. Further, new IDS must capable to deal with nonlinear behavior of malware datasets and model must have better fitting ability. Therefore, in order to protect and avoid vulnerable attacks, we would like to contribute an implementation of a deep learning algorithm - Extreme Gradient Boosting (XGBoost) and Recurrent Neural Network (RNN) - on Microsoft Malware Classification Dataset (BIG 2015) datasets. Also, BIG 2015 raw datasets will be preprocessed and resized to make the data compatible to these algorithms. Moreover, the performance of these algorithms will be measures and compared using these parameters - Accuracy, Precision, Recall, F1 score, Loss, True Positives, True Negatives, False Positives, and False Negatives, and receiver operating characteristic (ROC) curve by calculating the AUC (the area under the ROC curve).

Magnetic Levitation in Motion

Jesse Miller (McCullough Jr. High School, The Woodlands, TX, USA)

This project analyzed the physics of magnetic propulsion by modeling the propulsion system of a MagLev train. A scale model was created using electromagnets to simulate the attracting/repelling forces that cause MagLev trains to move. The speed of the model train was recorded as a function of the pull force of the electromagnets. A magnet strength equivalent to 11 pounds of pull force was shown to produce the most cost-effective results.

Next, the levitation system of a MagLev train was studied by creating a scale model of a track using neodymium magnets. The levitation height was measured as a function of the pull force of the magnets. No strong increase in height was observed.

Thousands of people use MagLevs daily in Japan. In Japan, MagLevs shorten travel times for commuters significantly, in

addition to decreasing traffic congestion and pollution on busy freeways. Many countries, including the US, are planning to build MagLev trains to reduce travel times in their countries. The same principles tested here can be scaled up and applied to real MagLev trains in order to make travel faster and more cost effective for the average citizen.

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