THE GOVERNOR'S SCHOOL
for
SCIENCE AND TECHNOLOGY

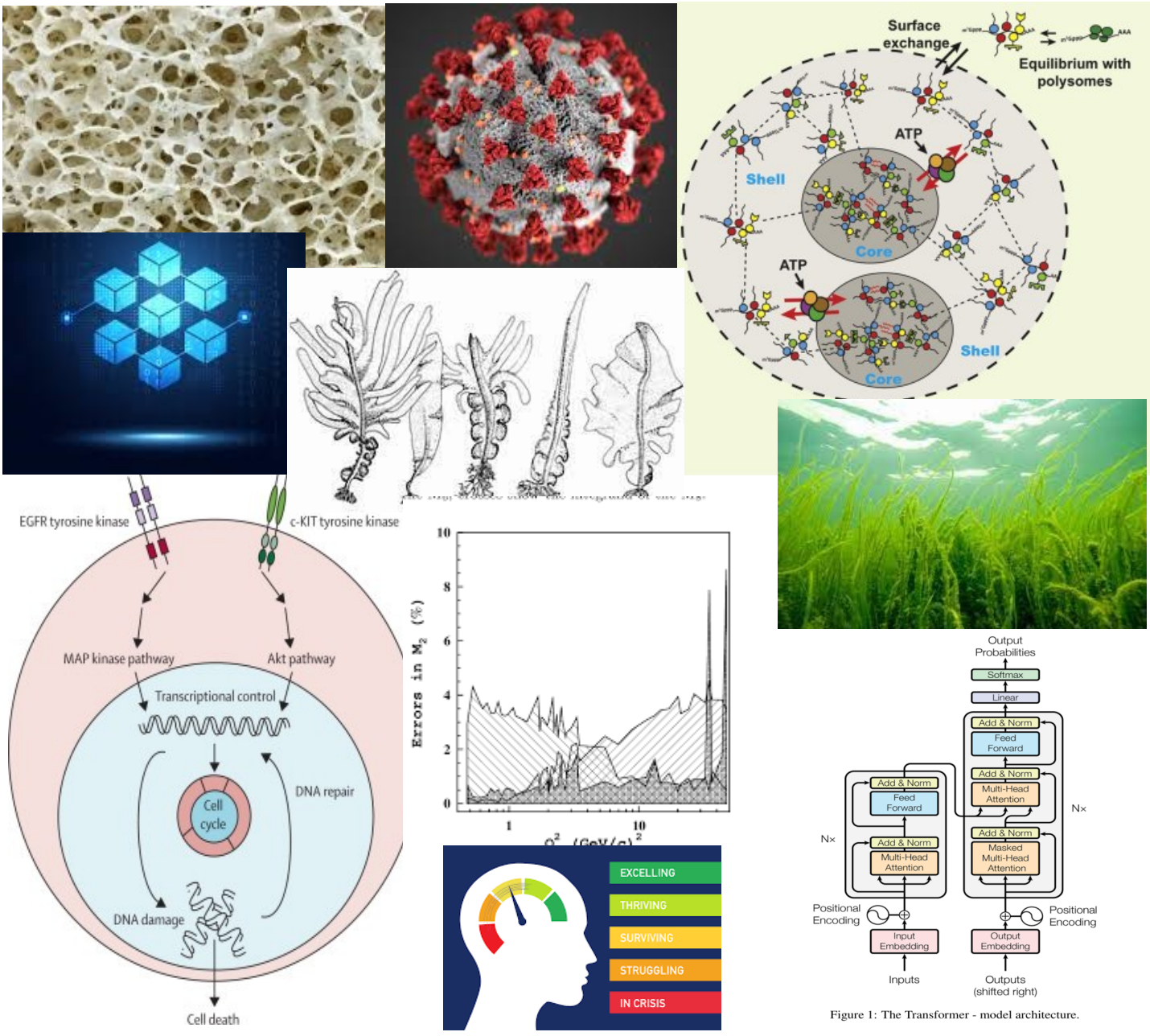


Figure 1: The Transformer - model architecture.

2021 Science Research Journal

Transformer-Based Deep Learning Architecture for Android Malware Classification and TTP Prediction

Abstract

Transformers promise groundbreaking advances in deep learning by allowing models to generalize and form a sequence better than ever before. While typically constrained to Natural Language Processing (NLP) tasks, this study applies Transformers to Android malware posing a unique, multi-task approach to malware classification, technique prediction from time-series dynamic analysis, and context from MITRE's ATT&CK. The model would use the encoder outputs for classification and the decoder element to predict technique chains with a diverging transfer learning element allowing the two to generalize, then separate and fine-tune. Compared to previous research into deep learning and cybersecurity, expected results from the proposed architecture improve on traditional networks. This led to yielding 98% accuracy in malware classification, as well as 99.9% accuracy in technique prediction (on training data only). The expected findings support the utility of Transformers in use cases beyond NLP and provide a method for anti-malware to detect malicious activity in real-time via malware techniques.

Andrew Balch
York High School
York County Public Schools

"This was an experience I will never forget that taught me valuable lessons about professional software development, collaboration, and setting realistic timelines."

"...expected results from the proposed architecture improve on traditional networks yielding 98% accuracy in malware classification and 99.9% accuracy in technique prediction..."

Andrew will be attending University of Virginia

The Effects of the COVID-19 Pandemic on Physical Activity and Sedentary Behavior of U.S. High School Students

Abstract

State and local social distancing restrictions caused by the COVID-19 pandemic have resulted in numerous gym, recreational facility, and park closures that have altered the lifestyles of adolescents. While these measures were needed to slow the spread of disease, they may have caused a negative effect on physical activity and an increase in sedentary behavior. This study aimed to quantify the impact of the COVID-19 pandemic on physical activity and sedentary behavior in a sample of U.S. high school students between the ages of 16-18 before and after the pandemic was declared a national emergency. Participants (N=67) completed the validated Godin Leisure-Time Exercise Questionnaire and the International Physical Activity Questionnaire, which assessed physical activity and sedentary behavior before and after March 13, 2020 (date the U.S. declared a national emergency). Paired t-tests were used to assess the difference in means for pre-pandemic and post-pandemic health behaviors, and found a 37.4% decrease in total physical activity and a 23.2% increase in sedentary behavior. The findings support the theory that the COVID-19 pandemic and resulting restrictions have negatively impacted the physical activity and increased sedentary of behavior of U.S. adolescents.

Darrian Belcher
Bethel High School
Hampton City Schools

"The GSST mentorship program has helped me develop valuable research skills that will be beneficial in both college and my future career."

"...the COVID-19 pandemic and resulting restrictions have negatively impacted the physical activity and increased sedentary behavior of U.S. adolescents."

Darrian will be attending North Carolina Agricultural and Technical State University

Blockchain in Education: Using Voting Smart Contracts for University Governance

Abstract

This project focused on implementing blockchain more extensively in higher education. Research conducted by EduCTX, Holberton Software Engineering School, and MIT explored the use of blockchain for credentialing, but the scope of using blockchain in higher education was somewhat limited. The College of William & Mary's Blockchain Lab proposes expanding blockchain's use through a university governing blockchain-based service called Decentral-U. This study aimed to prototype a smart contract compatible with Decentral-U that would allow stakeholders to vote on syllabus approval. The resources used are Solidity, Truffle Suite's Ganache, SIMBA chain and IPFS. The model proposed in "Solidity by Example: Voting," was modified to allow one syllabus submission at a time, prevent vote delegation, prevent the withholding of votes, and record the instructor who submitted the syllabus. The contract compiled and deployed, with deployment consuming 548369 gas the function which grants voting rights to consuming 25520 gas, and the function which cast a vote consuming 49886 gas. The successful compilation and deployment indicated that the contract could interact with an established blockchain. The contract's gas consumption was successful relative to the "Solidity by Example: Voting" model, which consumed more gas in its deployment and function calls. It was expected that institutions of higher educations will judge the voting system as appropriate for a university setting. The contract should serve as a satisfactory model for future work.

Elizabeth Chason
Lafayette High School
Williamsburg—James City County Schools

"I am so thankful to have been able to study blockchain during its rise in popularity. This experience has helped me realize a passion for data structures and cryptography, which I hope to pursue further in college."

"The contract should serve as a satisfactory model for future work."

Elizabeth will be attending Vanderbilt University

Additive Manufacturing of Bone Composite Materials

Abstract

The focus of this project is to find an alternative method for fixing bone defects and replacing bone in an animal's skeletal system. The current method used worldwide is the implementation of metal plates into the skeletal system. With research, it was determined that this method was obsolete. A better way is to implement a bone composite material that can mimic bone and is biodegradable. This experiment uses a polymer that is mixed with bone and then 3D-printed to substitute the metal plates. Testing the mechanical properties of stress and strain on each variable combination of bone particles and polycaprolactone (PCL) showed how well the bone composite would exist in the body. The best combination was a composite composed of 40% PCL and 60% bone. This combination was determined to be the best due to the fact that it had the most desirable mechanical properties out of all five combinations.

Ian Claville
Menchville High School
Newport News Public Schools

"My mentorship with Dr. Jerald Dumas was very fulfilling and had a heavy influence on my major in college. I learned a great amount, and I plan to be still involved in the research we conducted. If I had to do it again, I would definitely take the opportunity without hesitation."

"A better way is to implement a bone composite material that can mimic bone and is biodegradable."

Ian will be attending Howard University

Music Streaming Rhythm Game

Abstract

Rhythm games are a specific genre of the wide range of computer games available today. Specifically, it is a game where the player is expected to learn the rhythm of the music and hit the beats/ notes that appear on the screen in the correct manner—time, direction, movement, etc. Instead of being limited with a set list of songs that current rhythm games have, a music streaming rhythm game (MSRG) would allow people to choose the songs they want to play. This is different from existing rhythm games because the beat maps are not required to be made before the user can play. This would be done by intaking a streaming source in chunks, and then analyzing each chunk to dynamically create the beat maps for the game. Because the dynamic creation of beat maps allows for the song to be analyzed while the user is playing, any song can be chosen. The MSRG was not fully implemented, but most core concepts were proven possible: intaking the streaming source in chunks and getting playback. A rhythm game that allows players to choose songs they like and want to play would appeal to a variety of people. This study concludes that the creation of a MSRG that allows players to choose songs is viable.

Indira Durham
York High School
York County Public Schools

"I had a great experience with my mentorship. My mentor encouraged me and helped me throughout the process, but also pushed me to be the best that I could be. It enabled me to do more than I thought I could. "

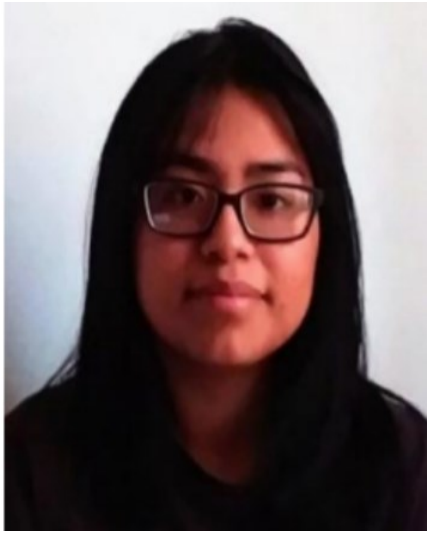
" ...the creation of a music streaming rhythm game that allows players to choose songs is viable."

Indira will be attending Pratt University

Analyzing Phosphoproteins in African American and Caucasian Cells in Relation to Triple Negative Breast Cancer

Abstract

The field of cancer research has been developing rapidly in hopes of finding reliable treatments. Triple negative breast cancer (TNBC) is a very difficult cancer to treat due to its lack of receptors. The goal of this study is to understand racial disparity in TNBC in hopes of finding an effective treatment. TNBC has a higher mortality rate in African Americans than in Caucasians, meaning that there are some cell signaling pathways that Caucasians have and African Americans may not have. The codes of the phosphoprotein are analyzed using different types of online databases to find any underlying factor as well as their signaling pathways. This can help determine why there is a higher mortality rate in African American individuals in comparison to Caucasian individuals. It is important to understand the racial disparity in triple negative breast cancer in order to find potential efficient treatments.



Maria Fernandez
Tabb High School
York County School District

"My mentorship experience has given me the opportunity to apply my data analysis skills in a professional environment by providing me with real life research."

" It is important to understand the racial disparity in triple negative breast cancer in order to find potential efficient treatments.

Maria Fernandez will be attending VCU

Biomimetic Adhesive for Biomedical Application:

Abstract

The aim of this study was to provide a review of the current status of the biomimetic adhesives that have the potential for clinical application. Biomimetics emulate compounds with a biological origin without exhibiting the negative attributes. There is a need for biomimetic adhesives due to the toxicity and shortcomings of synthetic adhesives and metal tools. Bonding living tissues has proved to be difficult due to the negative immune reactions to foreign materials and the wet environment of the damaged area. Biomimetics have grown to be more relevant due to biocompatibility implications and a less damaging impact on the environment. Despite differences in developmental approaches and organismal properties, these adhesives present potential for biocompatibility and functionality in wet environments. The review consisted of articles sourced from the PubMed database and references from related articles. Standardization of an efficient production method for an effective biomedical adhesive should be the next step for future research.

"There is a need for biomimetic adhesives..."

Elianne Kang
Jamestown High School
Williamsburg-James City County
School District

Sherine Kim
Grafton High School
York County School District

"Our mentorship involved researching biomimetic adhesives for usage in surgery, inspired by natural resources and animals. We were able to write and submit a review article to a publishing journal with the guidance of our mentor, Dr. Dua. It's been a unique learning experience, and a great opportunity for collaboration and research."

Elianne Kang will be attending Duke University & Sherine Kim will be attending UCLA

Travelerization: Automated conversion of Travelers to Cold Fusion

Abstract

Travelerization is the concept of taking a traveler written by an engineer and transforming it into a reusable form on a web portal to allow repeated input of the data into a database. This is a complex task. When creating forms, each form needs to be created manually using either WPF or similar system, which would then be customized and designed to fit with the existing database and web infrastructure. Each part would be carefully scrutinized by a software engineer to prevent SQL injection, malicious file uploads, and any other range of attacks. Even after this process, software engineers often miss something and compromise their systems, such as incorrectly written prepared statements or scannable network secrets. They are also required to work with code minification, encryption standards such as TLS, and domain protection services such as Cloudflare. All U.S. Government contractors are required to adhere to security policies, the most notable of which are NIST-171 and CMMC (Webmaster, Cybersecurity Maturity Model Certification 2020). When using all of these systems, downtime is inevitable, and downtime costs money. To reduce the high cost incurred during downtime, the researchers designing the Pansophy system used a simple but effective solution. It's the same solution that U.S. voting machines use to protect the election: network isolation.

Cole Matthes
Warwick High School
Newport News Public Schools

"Speak up, ask for what you want, and challenge yourself with your project. Dalton is known for his unrefined attempt at something difficult, not a perfect attempt at something easy."

"When creating forms, each form needs to be created by hand using either WPF or some similar system, which would then be customized and designed to fit perfectly with the existing database and web infrastructure.

Cole Matthes will be attending Virginia Tech

Removal of Lead from Water Using Edible Marine Algae (*Undaria pinnatifida*)

Abstract

Water security is becoming a significant issue as industrial waste containing heavy metals is disposed in bodies of water. A method to efficiently remove lead from water was explored by immobilizing *U. pinnatifida* into beads and wires using sodium alginate and calcium chloride. Using immobilized *U. pinnatifida,* the effect of various factors on Pb removal efficiency and underlying biosorption mechanisms was investigated. Pb biosorption data were obtained and analyzed using best-known Langmuir isothermal and thermodynamic models as functions of *U. pinnatifida's* maximum Pb absorption capabilities of the algae. In addition, a thermodynamic study indicated that biosorption processes were found to be endothermic. An increase in the Pb solution temperature positively affected Pb biosorption. By controlling the amount of *U. pinnatifida* beads and Pb solution temperature, close to 100% Pb removal efficiency was achieved to develop an inexpensive yet efficient Pb removal system.

Hannah Namkoong
Tabb High School
York County Public Schools

"Mentorship helped me narrow my interests through hands-on research. It challenged me to think critically and creatively while gaining valuable knowledge in the career I want to pursue."

"Data analysis showed Undaria pinnatifida's maximum Pb adsorption capacity (Xm) to be approximately 5 times greater than that of activated carbon indicating superior Pb removal capabilities of Undaria pinnatifida."

Hannah will be attending Johns Hopkins University

Evolution of the Nucleon Nachtmann Moments

Abstract

Nuclear theory is a developing field of research that concerns the interactions of quarks, gluons, and their interactions within nucleons. What makes research in this field so different from astrophysics or quantum physics is that there is no prevailing formula that can describe what we see like gravitic equations or Schrodinger's wave function. What does exist, however, are sets of data from experiments that are being used to search for such a model that describes this scale of the subatomic world.

In this study, in addition to the Jefferson Lab data, all other available world data on nucleon structure functions from laboratories such as CERN and Fermilab were collected. All the necessary software was developed from scratch using the CERN physics data analysis package, ROOT. And finally, nucleon moments as a function of Q^2, which describe nucleon structure in terms of quark and gluon interactions, were determined from the collected experimental data.

Samuel Palmertree
Poquoson High School
Poquoson City Public Schools

"Working with Dr. Albayrak has opened my eyes to the world of nuclear physics and the process of analyzing data from experiments in a lab, providing me with invaluable tools as I continue to seek out opportunities for research in the future."

"Extracting the correct constants that describe the changing moment of the virtual photon will be a great assistance in extracting structure functions from data and working towards a description of the interactions of quarks and gluons. "

Samuel will be attending Virginia Tech

Environmental Factors and Their Effect on COVID-19 Aerosol Travel

Abstract

Atmospheric aerosols are constantly affected by differing environmental conditions that can influence not only the concentration of these aerosols, but also how and where they travel. COVID-19 can be spread as an aerosol which begs the question of how environmental factors affect the travel of these COVID-19 aerosols. To understand the relationship between these aerosols and the environment, researchers suspended a saturated salt solution into the air to act as a tracer for COVID-19 and then recorded the concentrations of these particles, the distance at which they were recorded, and other environmental conditions such as ozone, humidity, temperature, etc. Statistically significant variables were determined and modeled in order to compare whether or not these specific variables had any significant effect on the travel and concentration of the suspended particles. It was shown that many atmospheric conditions recorded did not affect the suspended particles in a significant manner; however, it was concluded that COVID-19 aerosols are largely dependent on wind direction and speed. This confirmation of COVID-19 aerosol's travel dependence on wind provides the framework for further preventative measures in the area of public health. New precautionary measures can now focus on wind direction in the outdoors rather than specific atmospheric conditions present at any one time as they have little effect on how these aerosols move outdoors.

Jalen Pryor
Gloucester High School
Gloucester County Public Schools

"I am very grateful to have had access to research in chemical engineering before university so that I could have useful skills and knowledge about a field I wish to pursue."

"...it was concluded that COVID-19 aerosols are largely dependent on wind direction and speed."

Jalen will be attending University of Virginia

The Relationship Between Shoreline Condition and Submerged Aquatic Vegetation Habitats

Abstract

Submerged aquatic vegetation (SAV) has many important functions in aquatic ecosystems including absorbing excess nutrients and providing food and habitat to various fish species. However, SAV habitats are currently declining. Shoreline armoring, the construction of hard structures along the shoreline to prevent erosion, may influence SAV health. The purpose of the study was to determine if there is a significant relationship between shoreline armoring and SAV abundance. The effects of marsh presence, beach presence, land use, and fetch were also studied. Geographic Information Systems (GIS) were used to map and analyze data sets created by the Virginia Institute of Marine Science. The GIS shapefiles included the 2009-2018 Chesapeake Bay SAV Coverage and the VIMS Shoreline Inventory (1998-2018) datasets. ESRI ArcGIS was used to conduct generalized linear regressions to determine relationships among SAV habitats and the explanatory variables. The JMP statistical software package was used to conduct a partition analysis to determine the importance of each variable in predicting SAV presence. There were no statistically significant relationships between SAV presence and the explanatory variables. However, the results can be used to explore the importance of the different variables in predicting SAV presence. The generalized linear regressions and partition analysis both demonstrated SAV occurrence. Although there was no significant correction, the regression tree showed higher probabilities of SAV in areas with a natural riparian land use. Information about the factions associated with SAV presence can help guide shoreline stabilization projects and determine areas best suited for SAV growth.

Maya Reece
Lafayette High School
Williamsburg—James City County Schools

"My mentorship at the Virginia Institute of Marine Science was a wonderful experience that allowed me to learn more about my career interests. I gained many valuable skills in GIS and geospatial analysis that can be applied to any career. Dr. Nunez was an amazing mentor who always encouraged me to explore my interests and keep discovering more about GIS and the environment."

"...the results can be used to explore the importance of the different variables in predicting SAV presence."

Maya will be attending University of Virginia

Determining the Domain Responsible for the Inhibition of Stress Granules

Abstract

The study investigated the effect of different plasmids on MK-STYX in HEK|293 cells to determine the domain responsible for the inhibition of stress granule formation. Six cases of plasmids were used to treat HEK|293 cells. The hypothesis was that the plasmid G3BP-GFP+MK-STYX-Ch2-mCherry would be most effective, therefore demonstrating that the CH2domain would be responsible for stress granule inhibition. Predicted results demonstrate that the G3BP-GFP + MK-STYX-Ch2-mCherry plasmid case had the least formation of stress granules. This implies that the CH2 domain is responsible for stress granule inhibition in MK-STYX. Completing this research in different cells could verify these predicted findings.

Danielle Sydow
Lafayette High School
Williamsburg-James City County School District

"Dr. Hinton did a wonderful job of making me feel included in the lab. I could tell that my fellow lab members valued my opinions and questions. I feel that it fully prepared me for collegiate-level lab work here at UVA and it was an invaluable experience. Additionally, I gained useful experience reading and interacting with scientific publications. "

"This implies that the CH2 domain is responsible for stress granule inhibition in MK-STYX."

Danielle Sydow will be attending University of Virginia

A Multivariable Analysis on Urban Youth Exposed to Violence

Abstract

This study has analyzed the correlations among sociodemographic factors, educational experience and exposure to violence as independent variables, and their effects on coping mechanisms and mental illness in urban youth. It is theorized that the independent variables promote negative impacts on mental health and coping mechanisms of adolescents. Survey responses from 500 urban adolescents within the Hampton Roads area in the State of Virginia was used to assess and analyze the independent variables and their effects on mental health and coping mechanisms. Outcomes from a series of multivariate analyses revealed that relationships exist between sociodemographic factors, exposure to violence, and types of coping strategies. Specifically, exposure to violence was found to be directly related to coping strategy in which individuals exposed directly and indirectly demonstrate diminished positive coping. Implications for school related intervention and suggestions for future research are addressed.

Christina White
Hampton High School
Hampton City School District

"My mentorship has not only built a foundation of skill to help in future research endeavors, but has provided me with the opportunity to analyze real-world issues impacting those of my own community. "

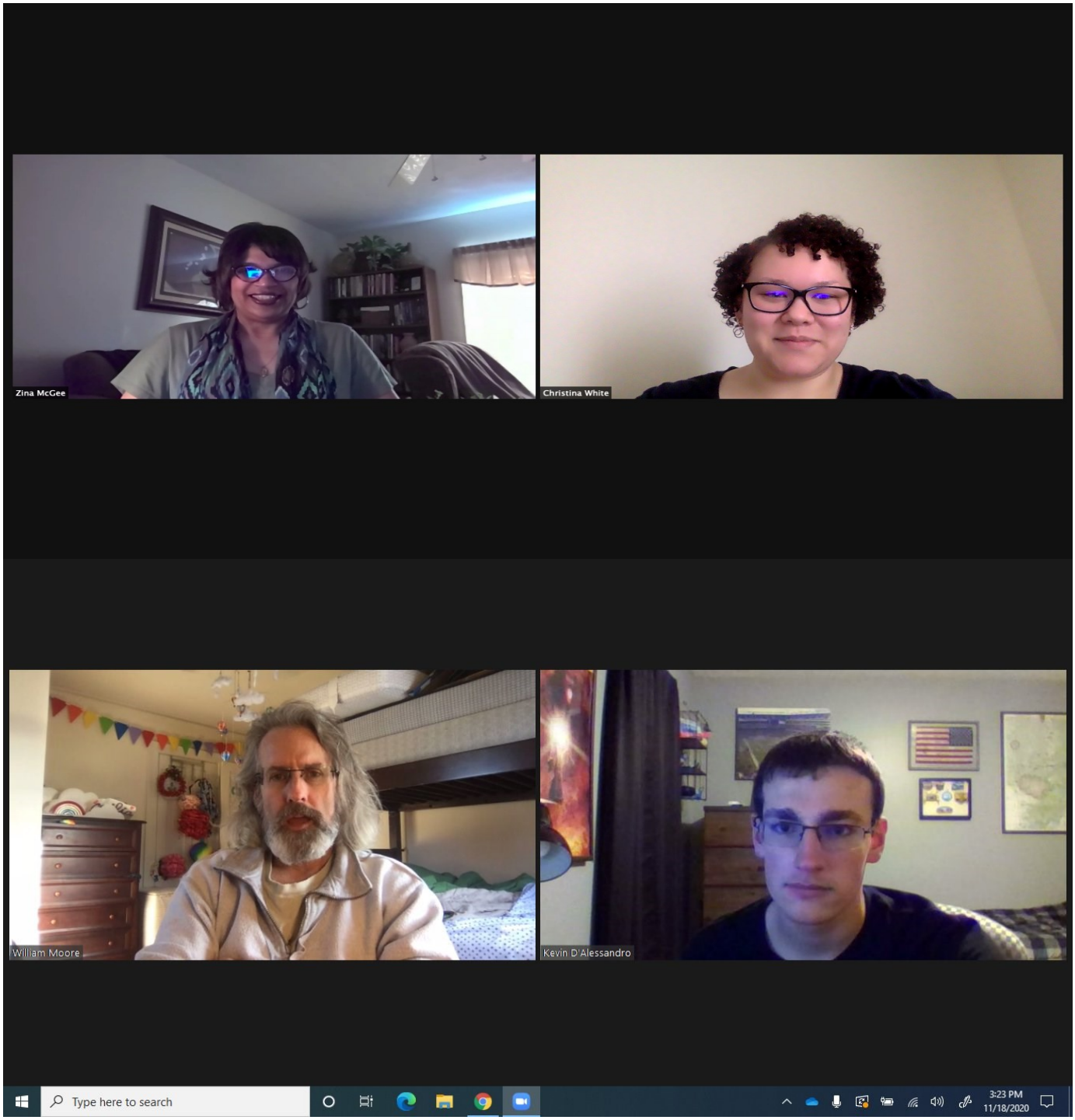
"Implications for school related intervention and suggestions for future research are addressed."

Christina will be attending Longwood University

Mentorship

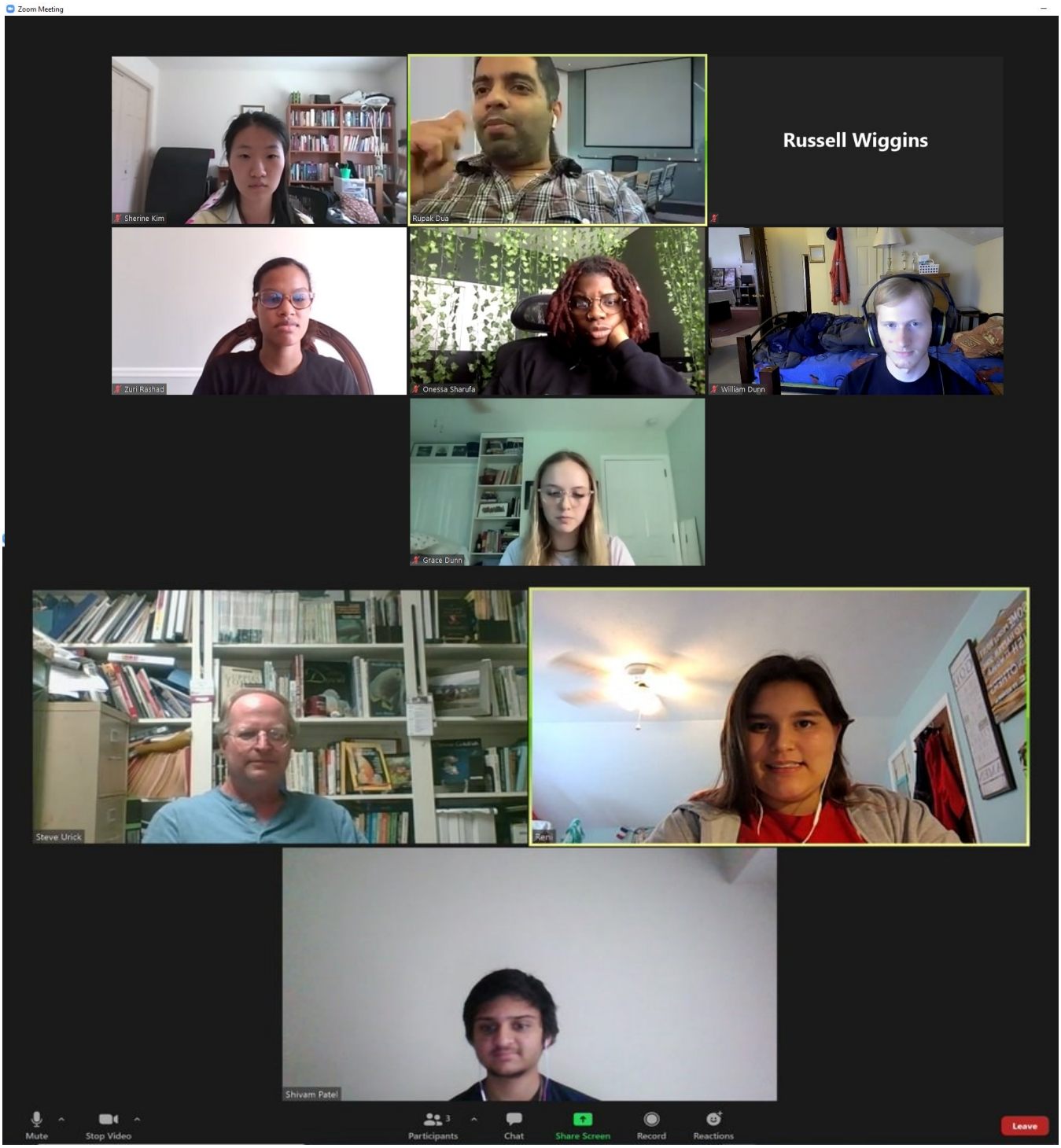
GSST students conducted research in the unprecedented virtual school environment…

Here's an example of what this looked like:



Experiences

Both students and mentors were both up to facing the challenge



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Research: Key Component of the GSST Student Experience

A primary goal of the GSST is to provide students with an opportunity to conduct serious scientific research, engineering design, or computer programming projects.

All students take a junior-year course in Research Methods and Ethics, which introduces them to research methodology, statistics, critical thinking skills, and the skills of scientific writing and presentation. In the junior year, all students prepare a science fair project for submission to the Tidewater Science Fair. Students are encouraged to take their work to additional state and national competitions.

In their senior year, students design and conduct a year-long research project under the direction of a professional in their field of interest. The field component is supported by an in-school course which guides students through the entire process, from the selection of a problem to the final presentation. Major aspects of the mentorship experience include: preparation of a formal written proposal for their project, oral presentation of the proposal and a status report at mid year to GSST faculty, a final research document, and presentation of final results to a panel of professionals in appropriate fields at the GSST Spring Symposium. In addition, many students present their findings at local, regional, and national science competitions and symposia. Exceptional work has been published in professional journals.

Research sites that have participated in the GSST Honors Research/Mentorship program included NASA Langley Research Center, Thomas Jefferson National Accelerator Facility, Virginia Institute of Marine Science, College of William & Mary, Hampton University, Christopher Newport University, Virginia Living Museum, local engineering firms, hospitals, and numerous of medical and professional specialists.

New Horizons
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