

Senior Projects

2023–2024



BASIS PEORIA



SENIOR PROJECTS

At this point in their senior year, BASIS Charter School students have completed a set of four BASIS Capstone classes to earn their BASIS Honors Diploma. In addition, many students are in the process of completing the College Board's AP Capstone Diploma™, a challenging, two-year sequence of AP Seminar™ and AP Research™, plus four other AP® Exams—all of which require extensive research, writing, and oral defense. The BASIS Diploma Senior Project marks the culmination of this hard work and perseverance.

Completed in the third trimester of a student's senior year, the Senior Project is unique, self-designed, and reflective of each student's varied academic interests and passions. Regardless of the discipline—business, art, humanities, science, engineering, social work, medicine, or law—each senior must develop and explore a research question. Creating an abstract that sets the tone of the research, participating seniors must submit a project proposal, and later, orally defend their methodologies.

Under the guidance of an external advisor who is a professional in their field, as well as a faculty advisor from their school, students dedicate 10–15 hours per week to the completion of their Senior Project. To document their journey, students post weekly blog entries about their experiences, successes, and challenges as they explore their guiding question. This journaling provides a unique viewpoint on the students' activities and adds a reflective layer to their research process.

Throughout the development of the Senior Project, BASIS Charter Schools support their seniors every step of the way. The project summaries in this publication clearly illustrate each senior's ability to apply the knowledge and intellectual curiosity they have acquired in the classroom to professional research methods. At the successful conclusion of this project, students are eligible for a BASIS Diploma with High Honors, the most distinguished accolade offered by BASIS Charter Schools.

Each member of the BASIS Charter Schools network commends our seniors for their dedication and motivation—not only for completing this Senior Project, but for their commitment to the BASIS Charter School Curriculum. Congratulations to them on this powerful achievement, and our best wishes as they move forward on their educational journey.



Carolyn McGarvey
Chief Executive Officer
BASIS Ed AZ, DC, LA



David Hubalik
Chief Executive Officer
BASIS Ed Texas



Peoria SENIOR PROJECTS

MATTHEW B.

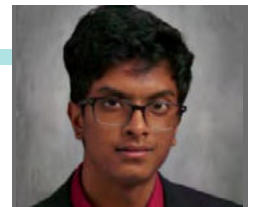


MODERN MEDIA: TRENDS OVER PASSIONS

SUMMARY: Trendy content often decides the success of news and entertainment media everywhere. The fine tools behind incorporating trends into writing is commonly referred to as search engine optimization (SEO). With popular media's sole success relying on viewers, it begs the question if the writers behind SEO content are just writing about the next trend? Do their passions ever line up with what they write about? Does marketable writing stifle the excitement a writer has for their job? Working with Tribune Wired for the past two months has given me a chance to observe exactly that. From first-hand experience and coworkers' words, it soon became obvious that SEO content often means setting your interests aside. Fellow interns across numerous age groups made it abundantly clear that writing in list form about the next show, beauty product, or travel spot can be pretty boring. With interns' general interests compared to writing content, there was rarely any alignment. We were all writing on subjects we knew little about, but for the sake of SEO content the articles were still produced. There's an interesting balance to be offered: list-form articles are quick and easy, making "non-interesting" topics go by pretty quickly without taking much energy from the writer. Trying to write about a passion is nearly impossible if it falls short of Google Trends—it's only a matter of carefully riding the popular media current, and writing on whatever can boost the relevance of your article.

• **BASIS ADVISOR:** Thomas Gebreyesus

ADHITYA C.



ASTEROIDS AND THE KOZAI-LIDOV EFFECT

SUMMARY: The motions of the asteroids in our solar system are very sensitive to the locations of the planets; the gravity of a planet can easily throw an asteroid out of its orbit (and potentially towards Earth). However, for some asteroids, the motions of the asteroid and the planets align in a perfect way so that something very interesting happens. Try as they might, the planets can't throw those particular asteroids out of their orbit; there is something "holding" the asteroids in place. This stabilizing behavior is called the Kozai-Lidov effect, and it's the topic of my research. By studying the Kozai-Lidov effect in detail, we can determine which asteroids may potentially be dangerous to the Earth and which ones are safe. This is the first step to protecting the Earth from life-threatening asteroids. I used a computer simulation to survey the entire asteroid belt for locations with asteroids under the Kozai-Lidov effect and for locations with asteroids that are in danger of being flung into the vicinity of the Earth. I found that in general, asteroids that are further out in the asteroid belt are more likely to be under the Kozai-Lidov effect, as are asteroids whose orbits are more circular. The trends in the stability of asteroids are more chaotic, but in many cases, asteroids under the Kozai-Lidov effect are much more likely to be stable than their counterparts.

• **BASIS ADVISOR:** Leslee Briggs

GENEVA C.



DISCREPANCIES BETWEEN FUNCTION OF PROSTHETIC AND BIOLOGICAL LIMBS

SUMMARY: What makes a good prosthetic? Is it how mechanically complex it is? Or maybe how easy it is for a person to use? Prior research has shown that it's not necessarily complexity that makes a prosthetic useful, as shown by the DEKA Arm, an arm unparalleled in its technical complexity at its time, but the amount of brainspace it took to recall how to manipulate and use the prosthetic left users unsatisfied and frustrated. However, simplicity also isn't necessarily the right answer. In my research, I'll examine a series of upper body prosthetics and determine what can be done to minimize discrepancies between the functions of prosthetics and biological limbs.

• **BASIS ADVISOR:** Melissa Georgi • **ON-SITE MENTOR:** Mark Thomas • **LOCATION:** Randy Whiteside Prosthetics

KESHAV C.



AUSTRALIAN MEDIA BIAS

SUMMARY: This paper addressed the possibility of bias that exists between developed and developing countries in regards to overly pessimistic or overly optimistic news from the perspective of a developed country, Australia. Specifically, we used a machine learning classification model to perform sentiment analysis on a set of news headlines with specific countries in the headline text and assigned a sentiment to each news headline. After assigning the sentiment, we cross-referenced between the country type (developing vs developed) and then compared the country type to the sentiment assigned to that specific headline. Finally, after analyzing the data, we made conclusions on whether or not there is an overly pessimistic or overly optimistic media ecosystem that exists between different types of countries and whether or not there is a correlation between the two variables (type of country and the sentiment associated with that country). The objective of this paper was to determine if there exists an artificially pessimistic bias in Australia's media reportings about developing countries in order to evaluate the extent of fatigued compassion in those developing countries. Fatigued compassion is the idea that the more pessimistic news that is associated with a certain country, the less likely people are to take action against crises in those countries. Fatigued compassion is not a desired outcome for news agencies because it influences the audience to take little to no action regarding certain events occurring in a developing country.

• **BASIS ADVISOR:** Leslee Briggs

RIA D.

DEFINING THE METAVERSE: ROBLOX GAMES

SUMMARY: With increased access to technology, questions about the educational potential of children's gaming platforms have become more relevant. Yet, literature about children's games disregards the substantial differences between each gaming platform, focusing instead on broad themes in gaming. In particular, despite its prevalence in children's entertainment, the gaming platform ROBLOX is understudied. This lack of specified literature leads to a gap in how researchers, game developers, and educators can use ROBLOX for engagement, education, and social awareness. My research aims to fill this gap in the literature by using a facet analysis method on the top 40 ROBLOX games to determine the commonalities in popular ROBLOX games. The facets that had foci with the strongest positive correlations with overall game popularity are gameplay, temporal aspect, art style, and game theme.

• **BASIS ADVISOR:** Leslee Briggs

RUSSELL G.

COMPARING THE PERFORMANCE OF TWO DISTINCT QUANTUM ERROR CORRECTION ALGORITHMS FOR HYPERBOLIC CSS CODES



SUMMARY: A major issue with implementation of practical, large-scale quantum computing that has recently emerged is that quantum bits, or qubits, are uniformly prone to error. Thus, for reliable computing systems to be created, there is a need for quantum error correction protocols that are capable of both detecting and correcting errors in these quantum systems. The most common way of doing this in the literature is a quantum code: an arrangement of qubits that are stabilized by so-called stabilizer qubits to correct for random errors. The stabilizer qubits detect erroneous bit flips and phase flips by measuring the qubits adjacent to them, which are then fed into an algorithm that tries to locate and correct these errors. There are many different studied variations of this structure. First of all, the arrangement of qubits can have different shapes. The first discovered and most researched shape is the toric code, in which the qubits are arranged in a grid with periodic boundary conditions, which means if you go off of one side of the grid you come back around to the other side. A variant of that shape is called the hyperbolic code, which has the same periodic boundary conditions, but the qubits are arranged, not in a square grid, but from a tiling derived from hyperbolic geometry. There are also different error correction algorithms. The two I am studying are Minimum Weight Perfect Matching, or MWPM, and a more recently discovered algorithm known as Belief Matching (BM). BM is believed to be more accurate (i.e. better at correcting errors) than MWPM, since it takes into account more of the available information than MWPM. The researchers who first came up with BM tested it on the toric code and found that it substantially increased the accuracy and practicality of error correction. However, since it is a newer algorithm, no one has tested BM with the hyperbolic code. In my research, I am testing the new BM error algorithm with the variant hyperbolic code shape, to see if it demonstrates substantial improvement over MWPM for that code shape.

• **BASIS ADVISOR:** Leslee Briggs • **ON-SITE MENTOR:** Dr. Norman Yao • **LOCATION:** Harvard University (Virtual)

AKARSH J.



AUTOMATING THE SECOND STRIKE: ASSESSING THE FEASIBILITY AND ETHICAL IMPLICATIONS OF AI-CONTROLLED NUCLEAR RESPONSE SYSTEMS IN THE UNITED STATES

SUMMARY: We're in a unique time in history where tensions are at an all time high between 3 super powers, the U.S., China and Russia. This is further compounded by the fact that all of these countries possess weapons that could cause the extinction of humanity if we are not careful with them. In order to minimize the amount of human error that could be possible with nuclear weapons, I decided to see if AI could be implemented in order to reduce the chance of human error. Previous research never went in depth into the feasibility of such an idea. Most of it tended to focus on how AI was used in the military and comparisons between countries and their nuclear arsenals. They also delve a little bit into what the consequences of such improvements are, focusing more on ethics. However, none of these papers discussed the feasibility of having AI in the nuclear arsenal, which my project aimed to solve. I did this by training an AI model to be able to distinguish the type of armament and the country it originated from in order to accurately respond to threats.

• **BASIS ADVISOR:** Leslee Briggs

NISHITH J.



THE IMPACTS OF ACOUSTIC ENVIRONMENTS ON SPINACH SEED GERMINATION

SUMMARY: Living beings interpret sound in many ways, and while animals create many complex interactions through communication or hearing, plants also interact with sound that can induce many signals like germination rate. Many components of sound waves such as attenuation, time period, frequency, and loudness can change the properties of a plant. A good example of those property changes are plants that are exposed to erratic noise pollution like car engines and sirens near streets had more stress and reduced growth than plants that grew in quiet environments. A contrasting example, however, was that researchers setting consistent, effective, and balanced sounds towards a plant had positive effects. One researcher's experiment that stood out from some examples was spinach where its yield and nutrients were significantly increased by sound technology. In my research, I examined the plethora of effects that sound does to plants, and I followed up on these studies with a new experiment by statistically comparing different sound environments on spinach seeds for germination. For comparing different sounds, I used three groups: no sound, single frequency, and music. Visually looking at the results of the experiment, it was clear that acoustic environments had an effect on a spinach's seed germination rate. Research around sound impact's towards plants is scarce, so with my results, not only will there be just more data, but also encourage more agricultural science communities to invest resources and research on sound technology and use it on wide-scale crop fields to their advantage.

• **BASIS ADVISOR:** Leslee Briggs

LAASYA K.



TRANSFORMATION OF DEINOCOCCUS DESERTI

SUMMARY: For my project, I will be looking at the bacteria, *Deinococcus Deserti*, and testing whether it can be transformed through electroporation or not. *Deinococcus Deserti* is a species of *Deinococcus* bacteria that was originally found in the Sahara Desert in Tunisia, Africa, and has since been found in other deserts, and other ecosystems. *D. Deserti* grows under conditions similar to the other *deinococcus* species, but it has pretty unique abilities which include cell regeneration from heat damage and high radioactive tolerance. The first step to working with any bacteria is transformation, and because of these characteristics and the fact that it has never been successfully transformed, I chose this as my project.

• **BASIS ADVISOR:** Leslee Briggs • **ON-SITE MENTOR:** James Tuohy • **LOCATION:** Glendale Community College

JYOTHISREE M.



ASIAN-AMERICAN DIVERSITY IN CHILDREN'S BOOKS IN PUBLIC LIBRARIES

SUMMARY: Libraries have made commitments to creating a more diverse collection and this is encouraged by the American Library Association. They strive to add more diverse books to their collections, and the diversity available is evaluated by genre or is looked at overall in a diversity audit. Previous diversity audits done in public libraries have focused on overall diversity in individual libraries and I talked to the children's librarian for the Phoenix Public Library system to see what I could investigate. I am looking at the Asian American and Pacific Islander diversity for elementary-age children. The objective is to see if this particular demographic is sufficiently represented by reflecting the Phoenix area in the library system's book collection available to children in that age bracket.

• **BASIS ADVISOR:** Leslee Briggs

MOUNIKA M.

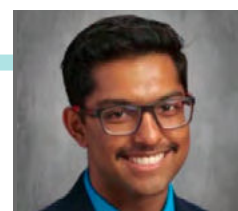


SOCIAL INFLUENCES IN COLLOQUIAL ENGLISH SPEAKING AMONG DIFFERENT GENERATIONS OF NEW MEXICAN NATIVE AMERICAN TRIBES

SUMMARY: After presenting my seminar individual project on high unemployment on Native American Reservations, I was left unsatisfied, wanting to explore other aspects of the community, while combining it with an interest of mine. As an avid writer and book lover I had always enjoyed my English classes; throughout all of these classes however the content of the writing or its written structure was the focus, so I decided to push myself and explore linguistic aspects of speech such as pitch, intensity, and rate of speech. Although linguistics is now part of the BASIS curriculum, I had never personally experienced it, and therefore now work alongside linguistic teachers as I conduct research using methods that even they are unfamiliar with. My research combines these interests as I examine the English dialects of various Native American speakers in New Mexico. It consists of a syntactical analysis, taken from annotation methods I had learned in English classes, as well as acoustic analysis, dealing with pitch and intensity. Because these recordings were interviews where the subject was asked to recall some sort of a story, I was able to compare the storytelling styles and methods used by different age groups. The data, in the form of sonograms, graphs, annotation calculations, and qualitative analyses allowed me to determine the linguistic (syntactical and acoustic) influence apparent in multiple generations, allowing us to understand the importance of storytelling within the community. This method was particularly eye-opening as instead of simply understanding the importance of the content of a story or how it was written, I was able to see its importance from a linguistic perspective. In this way, it almost connected the skills I have learned in my Language and Literature classes to linguistics, something that students currently are not able to completely grasp in the BASIS Curriculum. As enlightening as the experience was, I know there is much more to research in this area, so I hope to continue this pursuit in my collegiate years, maybe even recording my own interviews.

• **BASIS ADVISOR:** Leslee Brigg

ADVAY M.



HOW TO MAKE YOUR OWN SMOOTH OPERATOR

SUMMARY: When designing a car, a lot of thought goes into making it as efficient as possible, so it may have a higher gas mileage to appeal to the audience that appreciates reliability and gas mileage. Gas mileage itself is dependent on a few things, the engine itself and the aerodynamics. The aerodynamics are what dictate how much power a car needs to cut through the air at whatever speeds the car is expected to go. The more power, the higher the engine's crankshaft's revolutions per minute, the more fuel is used, resulting in a lower gas mileage. Thus it is necessary to design a car which can cut through air pretty efficiently. Wind tunnels are the simplest way to test aerodynamics by simulating environmental winds at differing speeds. Tests have been exhausted using normal sized cars, but it seems that no one has used the 1:24 scale models of the LEGO Speed Champions series; until now. I used these speed champions models in a proportional windtunnel and smoke to visualize what features, length or width or height or aerodynamic pieces, create the most aerodynamically efficient car. As the pathway of the smoke flows over the vehicles, the more visually smoother it looks, the more "clean air" is produced from the aerodynamics, which is indicative of an aerodynamically efficient model.

• **BASIS ADVISOR:** Spencer Kwit • **ON-SITE MENTOR:** Meghna Mathur
• **LOCATION:** Arizona State University, Industrial Assessment Center - West Campus

CHARLES N.



VIDEO GAMES & SOUNDTRACK ENJOYMENT

SUMMARY: As video games begin to branch into more corners of entertainment, it becomes increasingly useful to understand them and their social implications. While the topic of video games themselves have already been studied academically, their components remain especially under researched, so my research aimed to begin bridging this gap in knowledge by focusing on music in video games. Understanding the connection between music and the video game experience may help to make clear which audiences are more invested in the soundtracks attached to the games they play. Thus, my research determined the relative popularity of original game soundtracks (OSTs) between different video game genres on the Steam platform to evaluate whether, for specific genres, players were observed to more often listen to a game's soundtrack.

• **BASIS ADVISOR:** Leslee Briggs • **ON-SITE MENTOR:** Khalid Elssaad

ESTEBAN P.



THE DEPOSITION OF PEDOT ON BLACK PLATINUM

SUMMARY: If you've scrolled through the news recently, you've probably read about Elon Musk's Neuralink technology. But how is this technology possible? The answer is microelectrodes. Microelectrodes are tiny electrodes that can record and send signals to neurons in the body, and they could be revolutionary in developing new neural technologies. However, because they are so novel, there is much that needs to be done to optimize microelectrodes and maximize their utility. One of the major problems that microelectrodes face is that they have high electrical impedance (which is basically resistance to the flow of electrical charge) due to their very small size. This makes it very difficult for these electrodes to record electrical signals and function as they are supposed to. Past research has found that depositing PEDOT, a chemical substance, on the surface of electrodes significantly reduces impedance. However, PEDOT is mechanically unstable, and delaminates very easily from electrodes, making it unusable for long-term chronic applications. My research studied the deposition of PEDOT on black platinum (another chemical) to maximize the mechanical adhesion of PEDOT to the microelectrodes while also minimizing impedance. Specifically, I conducted multiple electroplating experiments, changing the amount of charge applied to the electrodes as well as the amount of time this charge was applied to find the point at which impedance was lowest. Through numerous electroplating experiments, I determined the optimal parameters to ensure that impedance was minimized via PEDOT deposition while also determining which parameters ensured maximum adhesion between PEDOT and black platinum.

• **BASIS ADVISOR:** Melissa Georgi • **ON-SITE MENTOR:** Oliver Graudejus • **LOCATION:** BMSeed in Mesa, AZ

ADRIJA R.



MODELING AND ANALYSIS OF FUEL CELL UTILIZATION EFFICIENCY UNDER LINEAR SILOXANE CONTAMINATION

SUMMARY: A solid oxide fuel cell (SOFC) converts the chemical energy of fuels, such as carbon monoxide, hydrogen and methane, into electrical energy at high temperature (1000–1273 K). Biogas is a potential fuel source for SOFCs due to its high methane content and renewable nature, but impurities such as hydrogen sulfide and siloxanes pose a serious threat to the performance and longevity of the anode. While the impact of hydrogen sulfides on the SOFC anode has received considerable attention, there are fewer studies on the siloxane contamination mechanism. Due to the cost of the materials and the experimental setup, significant effort has been devoted to developing models for SOFCs, several of which are available in the literature. In this study, the degradation of the solid-oxide fuel cell (SOFC) nickel-yttria stabilized zirconia anode under decamethyltetrasiloxane (L4) contamination is examined with experiments and modeling. A model is developed for the polarization losses based on the charge transfer coefficient, α , and diffusion layer thickness, δ , and fitted to the experimental data to understand how the siloxane degrades the SOFC performance with time. Focusing specifically on fuel cell utilization efficiency, the model is used to calculate changes in efficiency over time. These changes are mapped to physical changes in the fuel cell anode. Based on the physical changes we observe and the calculated changes, I will attempt to reason through a possible fuel cell degradation mechanism.

• **BASIS ADVISOR:** Leslee Briggs • **ON-SITE MENTOR:** Dr. Ryan Milcarek • **LOCATION:** Arizona State University, Industrial Assessment Center

AARUSH S.



BARKS AND MELODIES: THE EFFECT OF MUSIC ON DOG BEHAVIORS

SUMMARY: Many dogs are taken to the grooming salon everyday. Many of these dogs taken to the grooming salon typically see the salon as a very spontaneous stress situation. During the grooming process, they face showers, blow dryers, and combs. These grooming methods can be very stressful, loud, and harsh for the dogs so they begin to show signs of unhealthy behaviors like stress, anxiety, vocalization, restlessness, and aggressiveness. This will make it harder for groomers to actually groom the dog. For my research project, I asked volunteers to recreate a grooming environment in their own home. I asked the dog owners to record an initial behavior score for their dog before the grooming process. A higher behavior score meant that the dogs showed higher signs of unhealthy behavior. The dogs were then showered, blow dried, and combed. Halfway between each part of the session, the dog owner was assigned to play one song from a playlist that included jazz, classical, R&B, and dog music.

• **BASIS ADVISOR:** Leslee Briggs

ANSHULA S.



ESTABLISHING TRANSFORMATION PROTOCOLS FOR DEINOCOCCUS AQUATICUS TO ENHANCE BIOREMEDIATION AND GENETIC MANIPULATION

SUMMARY: My project aims to fill a crucial gap in the field of bacterial transformation. While other *Deinococcus* species like *D. Radiodurans* and *D. Grandis* have been successfully transformed using electroporation, this technique remains untested for *Deinococcus Aquaticus*. This research is being conducted to establish electroporation protocols for *D. Aquaticus*, paving the way for future applications in bioremediation and beyond. Current research lacks established methods for manipulating *D. Aquaticus*' genetic makeup. This limits our ability to harness its unique traits, such as extreme radiation resistance, for practical applications. The successful transformation of *D. Aquaticus* opens doors to introducing novel functionalities, like the ability to degrade nuclear waste. This study adapts existing electroporation protocols used for *D. Radiodurans* and *D. Grandis* to *D. Aquaticus*. Two different procedures will be tested, and their effectiveness evaluated based on colony growth on agar plates. The colony count data will be presented in a voltage-versus-procedure table, highlighting the most efficient method. Demonstrating successful plasmid transfer in *D. Aquaticus* paves the way for introducing targeted functionalities. For example, a plasmid encoding enzymes for nuclear waste degradation could equip *D. Aquaticus* with bioremediation capabilities. This project paves the way for future research exploring these exciting possibilities. The project's success will be measured by the number of transformed *D. Aquaticus* colonies obtained through each procedure. The protocol yielding the highest transformation rate will be deemed the most successful and reliable method.

• **BASIS ADVISOR:** Leslee Briggs • **ON-SITE MENTOR:** James Tuohy

CARMEL W.



HOW MICROGLIA PLAYS A ROLE IN ALZHEIMER'S DISEASE

SUMMARY: Alzheimer's (AD) is a type of dementia that causes an impairment in the cognitive functions of the brain such as memory loss. It is a common neurodegenerative disease in the U.S., with about 5.8 million Americans above the age of 65 suffering from AD and over 119,000 people dying of Alzheimer's in 2021. Some characteristics of AD include the β -amyloid protein forming plaques around the brain cells, tau protein tangles, a faulty blood-brain barrier, and brain atrophy. However, the exact cause of AD remains unknown. Many researchers believe that the cause of Alzheimer's is multifactorial and is not linked to one thing specifically. What I am researching is the link between mitochondrial dysfunction in the microglia and Alzheimer's. Microglia are immune cells part of the central nervous system and play a role in maintaining the CNS, brain infections, and response to injury. Mitochondrial damage and increased reactive oxygen species in microglia can lead to neuroinflammation which plays a role in the pathogenesis of Alzheimer's. There are potential therapies and treatments for Alzheimer's through further research on the role of mitochondrial dysfunction in the microglia in the progression and cause of Alzheimer's.

• **BASIS ADVISOR:** Charlotte Hagerman

ADHITI Y.



CHOREOGRAPHIC COMPLEXITY EFFECT ON AUDIENCE RECEPTION

SUMMARY: For my senior research project, I will explore choreographic complexity specifically of an Indian classical dance form and its effect on audience reception. I hope to do so through social media analytics (across different social media platforms) of dance groups that partake in this specific dance form. Overall through this project, I hope to find valuable information for choreographers and artists, helping them make more informed decisions about the level of complexity that resonates most effectively with their audience.

• **BASIS ADVISOR:** Leslee Briggs





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