Higher Education Research Council
Undergraduate Research Supplemental Funding
Boise State University
Final Report

Academic Year 2020-2021

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Introduction

The Institute for Inclusive & Transformative Scholarship oversaw the HERC Undergraduate Research Fellowship at Boise State University Fall 2020, and Spring 2021. HERC funds were used to support Boise State undergraduate students who had minimal research experience with a 10-week mentored research opportunity during the fall and spring semesters. Funds provided by the Higher Education Research Council supported a total of 17 students across 9 different STEM disciplines.

On behalf of the Institute for Inclusive & Transformative Scholarship, we thank the Higher Education Research Council for their generous support in helping build meaningful experiential learning experiences for Idaho students and supporting faculty research.

HERC Funding:

The Higher Education Research Council provided $51,000 in supplemental funding to support STEM undergraduate research at Boise State University this year. Please see the table below of how stipends and travel awards were dispersed.

Stipends	**Amount**	**Details**
Fall Semester Research Stipends	$24,000	8 students at $ 3,000 each
Spring Semester Research Stipends	$27,000	9 students at $3,000 each
Student Majors: Anthropology (3) , Applied Mathematics, Biology (2), Chemistry, Civil Engineering, Electrical Engineering, Engineering Plus, Health Science, Mechanical Engineering (3), Physics (3),		
Total	**$51,000**	

Fall 2020 HERC Fellow Boise State Student Abstracts:

Chithkala Dhulipati
Faculty Mentor: Dr. Michal Kopera, Department of Computing, Boise State University

Research Title: Simulations of Multi-Layer Shallow Water Model

In this work, we ran test simulations of different scenarios of the multi-layer shallow-water model and visualized the results in ParaView. Further, the results were compared to the reference solution, the HYCOM model, to see if Galerkin methods are competitive enough with other established numerical methods used for ocean modeling. Initially, we simulated a two-dimensional wave in shallow water equations and then expanded it into a two-dimensional wave in a two-layer system. We designed the two-layer model such that each layer had adifferent density. Further, we set up a perturbation on the interface between the layers. We could see that the disturbance propagated in the interface between layers, with faster waves traveling on the surface.We visualized the simulation results in ParaView by using various filters like append attributes, calculator, and warp by a scalar. Exporting this state of the simulation into a Python script helped create a contour plot. We compared this plot to the reference solution.

Ashley Maples
Faculty Mentor: Dr. Shelly Volsche, Department of Anthropology, Boise State University

Research Title: Do Leopard Geckos Bring People Together Through Social Media?

For this project, I will be digging into the psychological reasoning behind why certain mindsets are drawn into owning a reptile. Not only will this study better the knowledge of pet owners but why an owner leans towards a reptile pet.

Nathan McGregor
Faculty Mentor: Dr. Daryl Macomb, Department of Physics, Boise State University

Research Title: VRI Light Curves of BL Lacertae Objects

BL Lacertae objects' (BL Lacs) relativistic jets are oriented close to our line of sight, producing a variation in flux density over time. The physical mechanisms behind these fluctuations are still poorly known. Variability surveys such as ours that combine high photometric accuracy, sufficiently long-time baselines, and a high number of observation epochs hold the promise of significant progress. We present a pipeline as well as light curves that form the basis of a long-term photometric variability study of BL Lacs. We have expanded on our first set of photometric observations of Markarian 501, producing light curves for new sources. All BL Lacs were imaged in three optical (VRI) bands from 2010 to 2015 using the 0.4m telescope at the Challis Astronomical Observatory (CAO) in Idaho. Astrometric calibration was performed on each image using Astrometry.net. Images that were recognized and calibrated formed the data for our analysis. Artifacts were removed by resampling and co-adding images using SWarp. For each co-added image, we generated an SExtractor catalog and computed an on-sky separation by matching field stars with star catalogs. We used this solution to match each source to reference catalogs for modeling light curves. Future research will focus on multiwavelength observations, cross correlating these VRI light curves with observations in other wavelengths to better understand the source structure and physical processes of BL Lacs.

ShaKayla Moran
Faculty Mentor: Dr. Leslie Atkins Elliott, Department of Curriculum, Instruction, and Foundational Studies, Boise State University.

Research Title: Building Theories by Building Things

In the science classroom, curriculum often engages students in science experiments with predetermined materials and scaffolded instructions in order to obtain a designated outcome. However, science experiments like this focus on the product of experiment but not the process of designing an experiment. Implicit in these labs is that the goal of the science classroom is to learn specific scientific content instead of learning how to build theories and develop experiments in support of those. If, instead, we want science classes that support students in developing, vetting and refining theories, our research suggests that increased student agency around materials and design is critical. As students make design choices in their experiments, they enter into a conversation with materials and design and these inform and shape their developing models in richly scientific ways. Through the use of student examples we will show how students can use materials in novel and authentic ways that improve their design practice and solidify their scientific theories.

Carmen Pemsler
Faculty Mentor, Dr. Kendra Kaiser, Department of Geosciences, Boise State University

Research Title: Energy Demand of the Yankee Building

Working with the Lab for Ecohydrological Applications and Forecasting (LEAF) in the Department of Geosciences at Boise State University, we were able to determine the energy efficiency of the Yanke Research Park Building. Two different models were reviewed to automate the process of creating change point models for monitoring the energy use over time using the computational tool, Python. The first model, a 2P model, reflected a single linear regression model when fitted against a â€œcooling shapeâ€□ , where building energy use is positively correlated to outside air temperature. The second, a 3PC model (3P Cooling model), contains two slopes connected by a temperature change point. A changepoint was determined through iterations of the temperature data. Before the computed change point there is a zero slope and after the change point, a positive slope. This would take in consideration the building having no heating demand in cooler temperatures. We analyzed post-retrofit data provided by Idaho Power that included the hourly electricity use and the outside air temperature (OAT) from December 1, 2015 to December 1, 2016. The results from the OAT and electricity use data indicated that the Yankee building has some performance gaps in the way it utilizes energy.

Betsy Rosales
Faculty Mentor: Dr. Benjamin Johnson, Department of Electrical and Computer Engineering, Boise State University

Research Title: Wearable Bluetooth Interface for Flexible Piezoelectric Sensors

Polyvinylidene fluoride (PVDF) sensors are made of high-quality polymer that allows them to be extremely flexible when manufactured as thin sheets. Moreover, this low-density polymer exhibits piezoelectric properties, meaning it generates an electric charge in response to mechanical stress. Taken together, the flexibility and piezoelectric properties of PVDF sensors make them a promising solution for thin, lightweight wearable sensors that can be placed directly on the skin to monitor physiological activity. In this study, we established the viability of using a commercial PVDF sensor to detect physiological signals, such as arterial pulse. We integrated the PVDF sensor with a wireless Bluetooth low energy module to stream its voltage signal to a phone, resulting in a wearable sensor system for continuous data acquisition. We electronically connected our components with a printed circuit board (PCB) - designed using Eagle (AutoCAD). The sensor along with all our components were soldered onto the PCB to electronically connect and mechanically fasten them. This allowed the device to be solidified into a single piece making it easier and discrete to attach on to clothing.

Sierra Sandison
Faculty Mentor: Dr. Krishna Pakala, Department of Mechanical & Biomedical Engineering, Boise State University

Research Title: Alleviating the Negative Effects of Imposter Syndrome in Engineering Students

Imposter syndrome and feelings of self-doubt are common, even in spite of one's level of success. These feelings and thoughts can have detrimental implications for the sufferers. The purpose of this study is to gather data on how common and/or severe feelings of imposter syndrome and self-doubt are among engineering students, and examine whether or not knowing that their peers and mentors suffer from similar feelings will help alleviate their own. Our hypothesis include, (1) Engineering students underestimate the rate at which their peers and mentors suffer from feelings of self-doubt and imposter syndrome and (2) These feelings may be alleviated by discussing them more and understanding how common they are in others. The research will include students watching a mini-documentary of their peers and faculty being interviewed on their own experiences with imposter syndrome, and taking a pre- and post-survey on their own experience with self doubt/imposter syndrome and whether or not hearing about others' experiences affected the way they think about these feelings. The goal is to use this data to encourage students and faculty to be more open about their feelings of self-doubt in hopes that it will help everyone understand that these feelings are common. In addition to the results being presented at undergraduate research conferences and possibly published, the documentary shown to survey participants will also later be shown on campus and on social media, along with a discussion of the results of the study. Students will be emailed a survey that will assess their feelings of self-doubt and imposter syndrome as it relates to their engineering identity. The survey will use the Clance IP Scale. The participants will be asked to watch an ~11 minute mini-documentary of their engineering peers and faculty being interviewed about their experience with imposter syndrome. After the documentary concludes, participants will be asked to complete a post-survey assessing how watching the documentary affected their own feelings and opinions about their own experience with imposter syndrome and self-doubt.

Serena Sheldon
Faculty Mentor: Dr. Eric Brown, Department of Chemistry and Biochemistry, Boise State University

Research Title: Design and Synthesis of a New Ligand Scaffold Containing a Hydrogen-Bond Donor for Making Zinc-Hydrosulfide Complexes

Carbonic Anhydrase (CA) is a metalloenzyme that is present within numerous organisms. Although CA is responsible for the reversible hydration of carbon dioxide to bicarbonate, its lesser known function is the activation of carbonyl sulfide (COS) to produce hydrogen sulfide (H_2S). H_2S is an important molecule in biomedicine since it is a signaling molecule/gastrotransmitter. H_2S is produced in the body and has been shown to inhibit the formation of free radicals that are associated with aging and age-related diseases. The activation of COS produces a zinc(II) hydrosulfide in the active site of CA. However, the mechanism and the effect of hydrogen bonding interactions on the desulfurization of the zinc-hydrosulfide, to produce H_2S, are not fully understood. Our poster will discuss the preparation of a ligand scaffold containing a hydrogen bond donor and its successful use to prepare a zinc-hydrosulfide complex from COS gas.

Spring 2020 HERC Fellow Boise State Student Abstracts:

Alan Chavez
Faculty Mentor: Dr. Mahmood Mamivand, Department of Mechanical and Biomedical Engineering, Boise State University.

Research Title: Phase-field Modeling of Fe-Cr-CO Spinodal Decomposition

Research on non-rare earth magnetic materials was done at Boise State University's Computational Materials Design Lab, directed by Dr. Mahmood Mamivand. The objective was to develop simulation models using MOOSE (Multiphysics Object Oriented Simulation Environment) to model spinodal decomposition in materials at the mesoscale. The MOOSE framework is an open-source, parallel finite element framework developed by the Idaho National Laboratory. MOOSE makes modeling and simulations more accessible to scientists that have little background in computer science. Simulation models using MOOSE were done on the FeCrCo alloy using the phase-field method and the results were compared to experimental results from multiple sources. Next, simulations models were done using parameters from a different source compared to the original to make the simulations more quantitative for different compositions of FeCrCo. Simulation models were also done by implementing parameters that would take into consideration external magnetic field and demagnetizing energy of the alloy. When implementing new parameters found to create new simulation models for smaller compositions of CrCo in FeCrCo, it was initially thought that directly swapping parameters in the code would result in the expected spinodal decomposition. It was found that swapping parameters did not yield the results that we wanted. After debugging the code and using a mix of parameters from one source and another, results were still coming back inconclusive. After much thought, it was decided to instead focus on how the external magnetic and demagnetizing fields affect the spinodal decomposition of the alloy. Using the phase-field method and focusing on the total magnetic energy within the system, equations were found that would calculate the external magnetic field energy as well as the demagnetizing field energy. The external magnetic field energy was implemented first in the MOOSE code and it was found that it had little to no effect on the spinodal decomposition. This supports the argument that the spinodal decomposition will more likely be affected by the demagnetizing field energy of the system. Towards the end of the research, it was found that implementing the demagnetizing field energy proved to be more challenging than initially anticipated. Methods to overcome the challenges included simplifying the equations for the demagnetizing field energy and asking researchers from INL for insight on how to implement demagnetizing field energy in the MOOSE code. Future work will consist of successfully implementing the demagnetizing field energy along with the external magnetic field energy to create a more quantitative model that will allow us to compare the results with documented experimental results.

Andrea Feci
Faculty Mentor: Dr. Don Warner, Department of Chemistry and Biochemistry, Boise State University

Research Title: Rational Design of Small Molecule Lignads to Disrupt Protein-Receptor Interaction for the Treatment of Inflammatory Diseases

Overexpression of certain signaling proteins is the root cause of many inflammatory diseases, including skin, lung, and cardiac conditions, atherosclerosis, rheumatoid arthritis, as well as many types of cancer. Uncontrolled inflammation could be avoided by preventing those proteins —also known as cytokines— from binding to their membrane receptor so that the signaling is halted. To achieve that purpose, a drug could be designed to target the protein and change its structure; small molecule inhibitors (SMIs) can accomplish this job. These are ideally stable compounds with remarkable properties: membrane permeability, water-solubility, short half-life in the body, and ease of administration. This project focuses on developing a perfect drug that presents all the above properties, including optimal binding to the protein, which is quantified by a number called dissociation constant (K_D). A K_D is the ratio at equilibrium of the concentrations of drug and protein over the concentration of the drug-protein complex. Therefore, a lower K_D is indicative of tight binding and strong affinity. When this ratio is 1/100000, it is said to be in the low micromolar range, which is indicative of medium affinity. When this ratio gets a thousand times smaller, in the nanomolar range, the affinity of the ligand for the protein is very high. So far, over 50 compounds have been synthesized, with the lead compound having a 4.0 μM K_D score. For further improvement of the binding, 3D quantitative structure-activity relationship maps have been generated to intuitively summarize successful binding trends. Following those trends, a new generation of analogs is under development to lower the K_D to the nanomolar range and to improve the drug-likeness of the SMI.

Pangea Finn

Faculty Mentor: Dr. Daniel Fologea, Department of Physics, Boise State University

Research Title: Mechanical Stress Modulates the Ionic Conductance of Bilayer Lipid Membranes

The modulation of the transmembrane voltage of receptor cells using mechanical stimuli is an essential component of touch and hearing senses. Such stimuli influence the conducting state of mechano-sensitive channels, which in turn adjusts the ionic permeation and consequently the transmembrane voltage. The necessity of ion channels in these transduction processes seems obvious due to the non-conductive nature of a lipid membrane. However, our electrophysiology experiments show that a bare, artificial lipid membrane exposed to mechanical stress allows the passage of inorganic ions. We concluded that lipid membranes may constitute an important component of the transduction mechanism under mechanical stimuli.

Sarah Goldrod
Faculty Mentor: Dr. Erin Mannen, Department of Mechanical and Biomedical Engineering, Boise State University

Research Title: Biomechanical Differences of Moms and Non-Moms

During and after pregnancy, mothers biomechanically adapt their walking to account for the additional load of their baby. For example, their posture may change, and mothers can experience pelvic and back pain when carrying loads during walking gait. The effects of holding a baby in arms during walking gait is not fully understood. Two biomechanics studies have been conducted to understand how the mechanical constraint of holding an infant can impact the ground reaction forces of the caregiver. Understanding the body loading patterns is important for determining loads at specific pain-generating joints. The biomechanical differences of non-Moms and Moms during gait conditions needs to be further investigated. The 2020 study, *Infant Carrying Method Impacts Caregiver Posture and Loading During Gait and Item Retrieval* had 10 non-Moms walk across a flat surface at a self-selected pace in two conditions: (1) unloaded (holding nothing) and (2) in-arms (holding mannequin in a self-selected position). The ongoing 2021 study has 11 Moms walk across a flat surface at a self-selected pace in the same two conditions with the exception of the mom holding their infant instead of a mannequin. Motion capture systems, VICON (2020 study) and Qualisys (2021 study) were used to collect data. Multiple embedded force platforms were used to collect the forces exerted on the participants during the walking gait conditions. The peak braking forces and the peak vertical impact forces were analyzed through MATLAB and statistical tests. Peak vertical impact force was significantly greater during the in-arms condition compared to the unloaded. There was no significant difference between the moms and non-moms. Understanding the different walking patterns of moms and non-moms can help guide future experimental designs. This will allow researchers to understand if studies on non-moms can apply to moms and may lead to the development of interventions when moms experience pain during walking gait. Further investigations will compare other aspects of the studies like spatiotemporal parameters (step length, step time, stance time, etc.). To improve this study more statistical tests will be conducted on other gait conditions to confirm there is no significant difference between moms and non-moms walking gait.

Terra Green
Faculty Mentor : Dr. Shelly Volsche, Department of Anthropology, Boise State University

Research Title: Not Just a Walk in the Park: Dog Park Ethograms of Human-Dog Dyads

Introduction: Previous research demonstrates differences in owner sex and gender influence interactions with one's dog. Dog size also plays a key role. Using human parenting and human-dog interactions literature, we suggest that human-dog interactions may take the form of parent-child interactions, and that this can be observed and demonstrated using dyadic ethograms.

Methodology: We recorded interactions between guardians and their dogs at public, off leash dog parks in Fall 2020. We then selected 30 second focal follows and coded with continuous sampling. Independent variables included the sex of the guardian, general age cohort of the guardian (e.g., young adult, elderly), and the size of the dog. Coded behaviors included different types of play (e.g., chase, fetch, rough and tumble), parallel walking, and training activities. We also coded for times in which either the human or the dog engaged with others outside the focal dyad.

Main Findings: Our findings did not demonstrate specific differences between men's and women's interactions with their dogs. We suspect this may be a by-product of the particular park where recordings were made. However, there is evidence that human-dog interactions at the park mirror parent-child interactions. Dogs spent much of their time focused on, or playing with, other dogs, while humans either watched over their dogs or interacted with other dog "parents."

Principal Conclusions and Implications for the Field: The use of ethogram methods in observing human-animal dyads is still relatively new. However, this study demonstrates the value of this methodological approach. We provide further evidence to suggest that humans shape their relationships with dogs in ways that parallel parent-child relationships.

Julie Julison
Faculty Mentor: Dr. Mikael Fauvelle, Department of Anthropology, Boise State University

Research Title: Portable Art in the Great Basin

When we think about archaeology in the Great Basin, we usually don't think about art. If we do it is in the form of rock art, of which there is plenty, but there is another type that commonly gets overlooked, portable art. There are basically three forms of these small creative objects in the Great Basin: ceramic figurines, incised stones, and small rocks that have had their shape altered into what is believed to mimic some type of anthropomorphic animal. I would propose that some of these items may have been misidentified in the past and would like to put forth an alternative hypothesis, with related evidence for consideration. There are three figurines in particular which I will argue, two of these effigies are possibly grasshoppers, while a third may be a predaceous diving beetle. In addition to these re-examinations, this study will be adding to the increased dialog concerning insects in the subsistence strategies of Native Americans in the Great Basin. The importance of these food resources are then transferred and reflected in these portable art objects from archaeological sites, which provide additional evidence of their significance.

Tyler Lantz
Faculty Mentor: Dr. Julie Oxford, Department of Biology, Boise State University

Research Title: Effects of Doxorubicin on Cardian Fibroblasts and the Extracellular Matrix

Cardiotoxicity has been associated with various types of chemotherapeutic drugs contributing to a plethora of cardiac insults and is a significant side effect when treating cancer. Many highly effective anticancer drugs are severely dose dependent, and at higher doses can lead to: cardiac arrhythmias, hypertension, and lethal cardiomyopathy. A well known example of this cardiotoxic side effect is Doxorubicin, a common chemotherapeutic used to treat cancers of the breast, ovary, bladder, and thyroid. Extensive research has shown that high doses of doxorubicin detrimentally alters the normal function of cardiac fibroblasts and cardiomyocytes. In contrast to the extensive research on the toxic effects of chemotherapeutics like doxorubicin in cardiomyocytes, little is known on the effects in cardiac fibroblasts and mechanisms of these drugs on the cardiac extracellular matrix (cECM). We show that doxorubicin has a direct impact on cardiac fibroblasts and in turn the function of the cECM, indicating that the cECM plays an important role in cardiac toxicity induced by doxorubicin.

Rosana Lenhart
Faculty Mentor: Dr. Heidi Wu, Department of Physics, Boise State University

Research Title: 3D Shapes of Galaxy Cluster in TNG Simulations

Galaxy clusters are the largest structure in the universe, and their observed gravitational lensing signal can be used to study the formation of structure in the Universe.Â The 3D shape of galaxy clusters impacts the gravitational lensing signal generated by the cluster. However, the 3D shape has primarily been studied in dark matter-only simulations--without taking into account the impact of the gas. IllustrisTNG is a public project containing 18 hydrodynamic simulations of large sections of the universe. We have written code to determine the 3D shape of the clusters contained in the simulations. This work compares how the shape is affected both by the resolution of the simulations and the gas in hydrodynamic simulations.Â We find that gas tends to make clusters more spherical, while higher resolution tends to make clusters more elliptical.Â This project will help us understand how gas impacts the 3D shape of galaxy clusters. Moving forward this data will be compared with other simulations in literature.

Addie Totman
Faculty Mentor: Dr. Krishna Pakala, Department of Mechanical and Biomedical Engineering, Boise State University

Research Title: Using Sequential Art to Communicate Engineering Course Content

Course catalogs are notoriously hard to navigate, condensed, and confusing. In engineering especially, students rarely know what exactly a class entails until after they have enrolled and receive a syllabus. This can lead to students being discouraged by the courses they must take or drive away those that would like to pursue engineering but don't understand it. To combat this, we propose several full-page comics to illustrate the importance and content of selected engineering courses, written and drawn by a mechanical engineering student with knowledge of the classes that make up the base of the degree. The goal of these proposed comics is to demonstrate the basics of several courses while still being accessible to those who have not had previous experience. Comics have been used in classrooms to communicate complex ideas and are proven to increase understanding and connect to students better than text alone. They also can be a tool to promote diversity and show minority students that engineers can look like them.