

# McNair Scholars Program

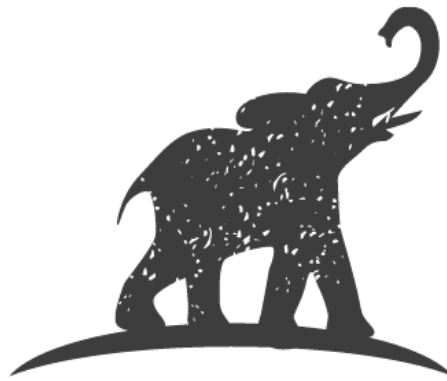
**2022-2023 • Volume 28**

**Journal of Research Reports**



**Continuing  
The Legacy**





If I have seen further, it is by  
standing on the shoulders of  
**Giants.**

# **McNair Scholars Program**

## **Continuing the Legacy**

### **2022-2023 • Volume 28**

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.....  
WICHITA STATE  
UNIVERSITY

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# Administration

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# From the Director

It is my honor to present volume 28 of the Journal of Research Reports, "Continuing the Legacy." This represents the culmination of 200+ research hours from each student. The breadth of research interests is as diverse as the students served by the McNair Program. The McNair staff and I could not be more pleased with the efforts that went into producing this meaningful and scholarly body of work.

The Ronald E. McNair Postbaccalaureate Program was founded to further the legacy of Ronald McNair, the second African American astronaut in space. After his death in the 1986 Challenger Explosion, his family approached Congress to propose that the McNair Program be established to promote the value of higher education and of bringing diverse voices into the field of academia.

In August 2022, the Wichita State community lost an incredible advocate for students. LaWanda Holt-Fields helped bring the McNair program to Wichita State in 1995 and she touched the lives of nearly 400 McNair Scholars who have come through the program. Before she passed away, she secured funding for the program for another five years, through 2027. It is my intention to further her legacy through the work that we continue to do through McNair Program at Wichita State. I had the opportunity to see Hamilton this summer, while I considered how to best characterize LaWanda's legacy. One of the final quotes hit home: "Legacy. What is legacy? It's planting seeds in a garden you never get to see." LaWanda planted a lot of seeds in the Wichita State community and beyond, in students who have gone on to complete graduate degrees across the nation. LaWanda's legacy will continue through the impact she had on these students and on her colleagues in TRIO and Wichita State.

I would also like to recognize the support of university faculty, staff, and administrators. Their guidance has inspired our Scholars towards completing research projects despite any obstacles they may have encountered and helped them to reach such great heights. Thank you for making undergraduate research a reality and supporting our McNair Scholars.

A special thank you is given to the staff for their dedication to the Program and the students that we serve: Ms. Sydney Wyatt, research coordinator, Audrey Scherrman, assistant research coordinator, Rebekah Aeschliman, writing tutor, and Ms. Carrie Hartzler, administrative specialist and all-around Program support. Lastly, I thank Ms. Deltha Q. Colvin, Associate Vice President for Special Programs, for her continued support.

Finally, I congratulate the students for a job well done; their efforts do not go unnoticed. They have taken this opportunity to share their brilliance with the academic community. These scholars are the future of America and I thank them for the opportunity to serve as their director.



# **Table of Contents**

## **WSU Administration**

Letter from Ashley Cervantes, Director WSU  
McNair Scholars Program

**2**

## **Research Manuscript**

**Octavio Pacheco-Vazquez**

**Elizabeth Behrman, Physics Department**

Scale-up of Grover's Algorithm Using  
Dynamic Learning Improves Quantum  
Speedup

**7**

## **Research Summaries**

**Ayshea Banes**

**Nick Solomey, Mathematics & Statistics**

Estimating the Ultra-High Energy Neutrino  
Flux from the Accretion Disks in the Galactic  
Core at Earth

**17**

**Ashley Bland**

**Bobby Berry, College of Applied Studies**

From Last to First: Elevating the First-  
Generation Student Experience

**21**

**Lindsey Choi**

**Thomas Luhring, Department of Biological  
Sciences**

Temperature's Effect on Microcosm  
Community Abundances

**27**

**Robbyn McKellop**

**Crystal Dozier, Anthropology Department**

Assessment of the Boxed Springs (41UR30)  
Ceramic Assemblage

**31**

**Julie Gonzalez-Morales**

**Marci Young and Danette Abernathy,**

**Counseling and Prevention**

#TeApoyamos: Preventing Suicide Spanish  
Training Efficacy Study

**35**

## **Extended Literature Review Summaries**

**Eduardo Avila**

**Jim Granada, School of Education**

The Effectiveness of Public Transportation  
and School Busing Programs on Student  
Absenteeism

**41**

**Jessica Carbajal-Sanchez**

**Samantha Slade, Psychology Department**

Efficacy of Interventions that Address  
Intimate Partner Violence in the Higher  
Education Setting

**45**

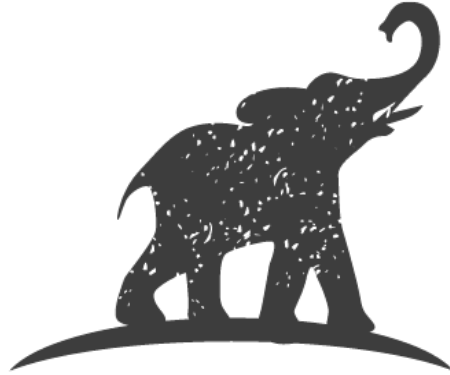
**Siubhan Mora-Bruce**

**Brigitte Roussel, Modern and Classical  
Languages and Literatures**

Language Change and the Call for a More  
Gender-Inclusive French

**49**





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*McNair Scholars Program*

**2022-2023**

Continuing the Legacy

# Research Manuscript







# Scale-up of Grover's Algorithm Using Dynamic Learning Improves Quantum Speedup

**Octavio Pacheco-Vazquez** and  
**Elizabeth Behrman, PhD**

Physics Department

## Abstract

Research has shown that certain quantum algorithms, such as Shor's Algorithm, have an exponential speedup when compared to their classical counterparts. Other quantum algorithms, such as Grover's Algorithm, have been proven to have only a quadratic speedup. This study seeks to find whether it is possible to increase the speed of Grover's algorithm. This research utilizes quantum algorithm setups constructed using freely available online quantum software, particularly IBM's quantum composer. The goal is to find a series of calculations that will be tested in MATLAB code for a small 2-qubit system. The final step will be to use the technique known as "bootstrapping," to use the information known from the small system on larger systems. Proving that certain quantum algorithms can be even further refined to show a greater amount of computational advantage confirms that our knowledge of quantum phenomena becomes more profound as research progresses in this field, and more real-world problems are able to be solved.

**Keywords:** Quantum Computing, Grover's Algorithm, Neural Network

## Introduction

Some of today's most successful technology companies such as Google, IBM, Microsoft, and others [1] use quantum computers. Although quantum computing is still in its infancy, the general public is not fully aware of its advantages. Quantum computers outperform their classical counterparts when asked to solve complex problems. For example, in 2019, Google proved that a calculation that would take thousands of years in the most powerful supercomputer could be done in less than four minutes using a quantum computer [2].

Classical computers work with a binary system called bits of 0's and 1's. These bits can be thought of as a switch: they can be toggled into a state of either on or off at any given time. Quantum computers work with qubits—or quantum bits—that also have states expressed through 1's and 0's; however, qubits can be in a superposition of both states at once. Furthermore, qubits can become entangled, which means that changing the state of one qubit would also change the state of every qubit it is entangled with—potentially altering thousands of qubits at once [3]. This is the main reason companies are now opting for a quantum solution to some of their problems.

Two main industry applications of quantum computing are in the cybersecurity and pharmaceutical industries [1]. IBM is currently working on constructing a secure quantum algorithm that is virtually unhackable. Although in this case, quantum computers are a double edge sword; they can be used to hack into some of the most secure supercomputers in the world. In the pharmaceutical industry, quantum computers are already being used to test new combinations of medications that can potentially cure several different conditions. Quantum computing is already changing the world.

Grover's algorithm provides a useful solution to unstructured search lists; its quadratic speed allows

the algorithm to find items in about  $\sqrt{N}$  tries where  $N$  is the number of objects in the list. This speed-up is significant, but not as significant as the exponential speedup that some algorithms—such as Shor's algorithm [4]—show for other types of problems. The goal of this research is to show that Grover's algorithm can be further refined to show a greater amount of computational advantage.

## Literature Review

Some may have heard the terms “quantum mechanics” or “quantum computing,” but few of these individuals truly know the specifics of what scientists in these fields study. Books, movies, and TV shows mention these terms and show strange worlds unlike ours, where time and space behave differently. In the most general terms, these ideas are correct, although there is a lot more to it.

People gain experience about their physical surroundings through everyday interactions [5]. One would expect macroscopic objects to be subjected to a set of rules that allow us to make predictions about their behavior and interactions with other objects. It is common knowledge that a rock will fall back down to Earth if tossed upward, a coin will not float if put on water while a piece of wood might instead, etc. These examples of simple interactions belong to what physicists call the classical world. Most people do not need an educational background to predict what might happen when two objects interact. Quantum mechanics is a completely different story, however. In most cases, making intuitive classical predictions will not help us understand the quantum system at hand.

One important thing to point out is that when the common ear hears the word “quantum”, they instantly relate it to something that is extremely small (microscopic), but this is not always the case. In some cases, quanta can be as big as the Earth itself [6]. The word quantum derives from the word “quantity”; the proper definition of quantum is: “a highly unified,



extended, specific quantity of field energy” [7]. A quantum can be understood as a bundle of energy that is constrained to certain values, i.e., it cannot have any continuous value. This will be better understood through an example:

When driving a motor vehicle with a speedometer, no matter how fast we accelerate, the speed will gradually increase. If the vehicle is going at 40mph and then accelerates to 60mph, the speedometer will read every single number from 40 to 60 without skipping any number, i.e., 40, 41, 42, . . . , 59, 60. If the vehicle were a quantum system, it could be possible for it to jump from 40mph straight to 60mph without having any of the values in between. Real examples where quantum systems exhibit these “jumps” include energy, angular momentum, spin, and others. The proper term for these properties of matter is to say that they are quantized [7].

As seen by the previous example, classical intuition will not always help us understand quantum phenomena. Quantum mechanics is the field that sets the mathematical tools used to understand and make predictions of quanta. Before an actual framework was proposed, physicists had already worked with experiments and theories that demonstrate the quantum behavior of nature, even though they were not fully aware of it. In 1801, Thomas Young worked on the double slit experiment, which demonstrates the wave nature of light and the quantum interference pattern shown on a screen [8]. Maxwell was extremely close to formulating a quantum framework in the 1860s when he was working on his electricity and magnetism equations; he would have been able to quantize his theory had he noticed one extra symmetry within his system. In 1900, Max Planck solved the ultraviolet catastrophe by assuming that energy comes in discrete packets rather than being continuously divisible [9]. Then in 1905, young physicist Albert Einstein used Planck’s idea to publish his paper on the photoelectric effect. Einstein was able to quantitatively explain

this effect, and he was the first ever to use the term “quantum” as referring to a physical object [7]. This discovery is often considered the birth of quantum physics. Since then, many others have expanded upon this pioneering work in quantum theory; however, this framework is still far from complete.

Quantum computing is composed of two major areas of study: quantum mechanics and computer science. Let’s turn our attention to the latter. Although people often think of computer science as something having to do directly with physical computers, this field goes a couple of thousand years back. It is hard to pinpoint when computer science originated. Some examples of early computations include the abacus created by the Babylonians around 2400 B.C.E.; as well as evidence of sophisticated logarithmic ideas also developed by the Babylonians around 1750 B.C.E. [10].

Computer scientists work with theoretical disciplines—such as algorithms, the theory of computation, and information theory— as well as some practical disciplines, like designing and implementing hardware or software [11]. The modern concept of computer science goes back to the 1930s with Alan Turing and Alonzo Church’s model, the Church-Turing hypothesis [10]. This model helps scientists understand the relationship between algorithms applied to physical systems and the mathematical concept of a Universal Turing Machine. Their hypothesis states that for any algorithm that can be performed on any piece of hardware (a computer for instance), there is an equivalent algorithm for a Universal Turing Machine which performs the same task as the algorithm running on the physical device. In other words, physical systems can be simulated by a universal model computing machine.

Based on Turing’s ideas, people started building electronic computers by the end of the 1940s. We know that computers and electronic devices in general have become significantly smaller since the 40s. Size

confinement was predicted by Gordon Moore in 1965; this gradual shrinking is referred to as Moore's Law [12]. This law explains that the number of transistors on a microchip doubles about every two years and the cost of computers is halved. Moore's Law has been accurate for the last few decades; however, progress has been stunted throughout recent years [13]. Transistors are approaching their minimal limit: the quantum limit. This is to say that the odd behavior of quantum physics starts to take effect on these devices, making them harder to control [12].

Scientists noticed the eventual failure of Moore's Law and began questioning whether there is a way to make computations more efficient without necessarily making components smaller. Here, the word "efficient" is used to mean runtime and computational power needed to run an algorithm. Inefficient algorithms usually take exponential time whereas efficient algorithms use polynomial time [10]. Using quantum mechanical properties on computational devices has the power to make computations more efficient, as theorized by David Deutsch in the 1980s [10].

About a decade later, scientists began to demonstrate that this is the case. In 1994, Peter Shor was able to solve a problem that was thought to have no solution on a classical computer; he was able to factor a given integer  $N$  in a polynomial time  $O(\log N)$ , where  $O$  is called the big  $O$  notation [4]. In 1996, Lov Grover was able to show that the implementation of quantum algorithms to unstructured search networks results in a quadratic speedup [4]. A quadratic speedup is not as significant as an exponential speedup, but very much worth studying. Grover's algorithm is the focus of this paper.

Unstructured networks are lists of  $N$  ( $=2^n$  where  $n$  is the number of qubits) items that are not organized in any way, but one of the items in the list has the desired characteristics that are sought. Often, literature refers

to this item as "the winner." If a classical computer attempted to find the winner item, it would have to search item by item and stop if found or continue if not. There are three important things to note [14]:

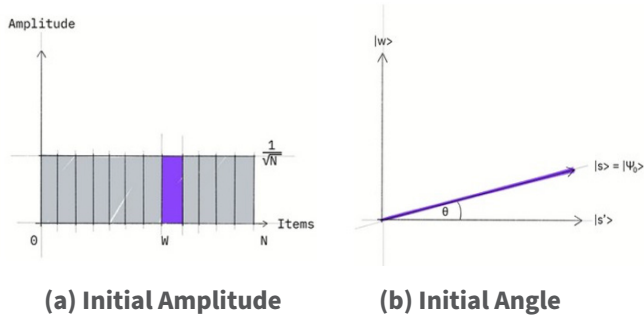
1. In the worst-case scenario, the classical algorithm would have to run  $N-1$  times if the winner is the last item in the list.
2. There is a probability of  $1/N$  finding any item.
3. On average the algorithm would have to run  $N/2$  times before finding the desired output.

The main difference is that Grover's algorithm is founded on the ideas of quantum parallelism, which involve quantum interference, and quantum superposition (Schrödinger's cat) [3]. Whereas classical probabilistic algorithms can be fully described solely with their probability vector, quantum algorithms cannot. This is because quantum algorithms rely on their amplitudes, which may be complex numbers. Thus, they may destructively interfere with each other. It is also important to notice that as the states are originally put in a superposition state, an operation performed on a state is an operation done on a superposition of states. These properties allow Grover to be faster than classical search algorithms.

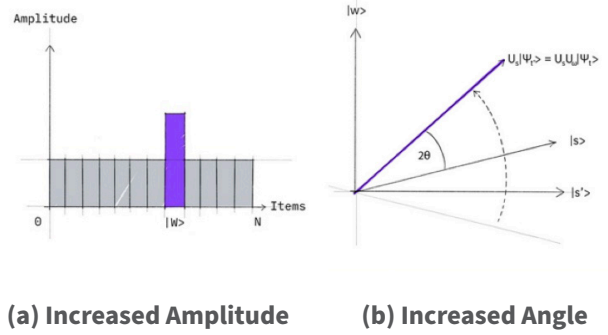
Using the properties mentioned above, one of the main steps in Grover's algorithm is to perform the inversion about the average [14]. This is an ingenious way of saying that the phase difference between the states is transformed into an amplitude difference. At the beginning of the algorithm, when the total number of states  $N$  are in a superposition state  $|s\rangle$ , they all have the same amplitude  $1/\sqrt{2^n}$ . Their average amplitudes become "balanced" as shown on Figure 1a. There, the winner item is represented by the  $W$  and colored purple. The plot in Figure 1b is a 2D representation of how far  $|s\rangle$  is from the winner state  $|w\rangle$  [15].  $|s'\rangle$  is in the span of  $|s\rangle$  and  $|w\rangle$  and is perpendicular to  $|w\rangle$ .



**Figure 1: Initial State**

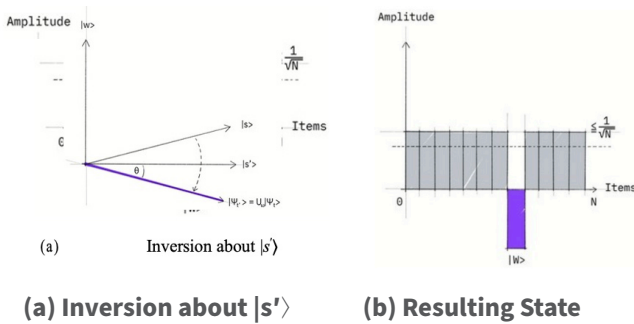


**Figure 3: Diffuser**



$U_w$  is then applied to  $|s\rangle$ , as shown in Figure 2. Figure 2a [15] shows how  $|w\rangle$  has been inverted about the axis. It is important that, since the amplitude of  $W$  has a negative phase, this lowers the overall average of the amplitudes (dotted line). Figure 2b shows the resulting state  $|\psi_t\rangle$  that has also been flipped about  $|s'\rangle$ .

**Figure 2: Oracle**



## Methodology

The purpose of this project is to study whether Grover’s algorithm can improve its quadratic speed. There are several steps that will help achieve this goal. The first major part of this study is based on the paper Experimental pairwise entanglement estimation for an N-qubit System [17]. The methodology for this is a slightly different, reverse way of redoing the work in the publication mentioned above. The paper starts with a definition of the Hamiltonian shown in Equation (1a) where  $X$  and  $Z$  are the Pauli operators, and the sub-indices  $A$  and  $B$  indicate operations/constants for qubits 1 and 2 respectively.

Then, the inversion about the average amplitude – also known as a diffuser– is applied to  $|\psi_t\rangle$ , as shown in Figure 3b [15]. The effect of  $U_s$  is to flip back the amplitude of  $|w\rangle$  about the axis but increase it while doing so as shown in Figure 3a. From Figure (3b) one can also see how the new state is closer to  $|w\rangle$  than  $|s\rangle$  was. For the repetition of the previous operations, the final state becomes the new  $|s\rangle$  and then applies both  $U_w$  and  $U_s$  again for the following iterations. Every iteration increases the amplitude by  $O(1/\sqrt{N})$  giving the overall  $O(N)$  speed up to the algorithm [14]. It is also important to notice that every time an iteration is completed the amplitude of  $|w\rangle$  grows linearly by approximately  $2k/\sqrt{N}$  when  $k \leq \sqrt{N}/2$  [16].

$K$  is the tunneling amplitude,  $\epsilon$  is the bias, and  $\zeta$  is the qubit qubit coupling. From Equations (1b-1d) it is possible to see the respective Hamiltonians for both the single qubits and the multi-qubit parts.

$$H = K_A X_A + \epsilon_A Z_A + K_B X_B + \epsilon_B Z_B + \zeta Z_A Z_B \quad (1a)$$

$$H_A = K_A X_A + \epsilon_A Z_A \quad (1b)$$

$$H_B = K_B X_B + \epsilon_B Z_B \quad (1c)$$

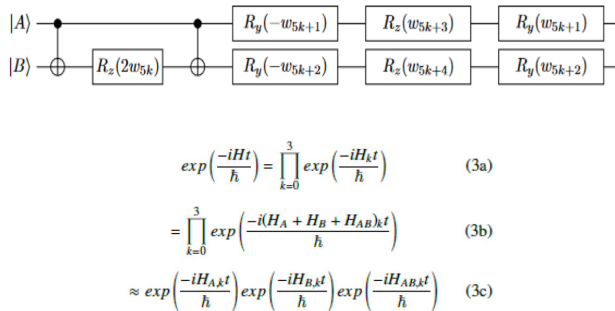
$$H_{AB} = \zeta Z_A Z_B \quad (1d)$$

The Hamiltonian advances in time a quantum state  $|\psi(0)\rangle$  (a quantum state at  $t=0$ ) with the regular time evolution operator in Equation (2).

$$|\psi(t)\rangle = \exp\left(\frac{-iHt}{\hbar}\right) |\psi(0)\rangle \quad (2)$$

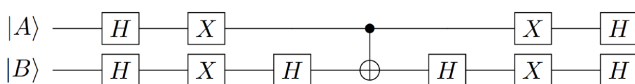
The following describes how the Hamiltonian is divided into "time chunks" where KA, KB, εA, εB, and ζ are held constant. The Hamiltonian can be expressed as a product of operators for k time chunks, Equation (3a). Time chunks are approximated as shown in Equation (3c). Starting with Equations (1a) and (2), several steps were done to arrive at a quantum circuit (Figure (4)) in terms of Rotation gates Ry(θ) and Rz(θ), and 2 CNOT gates (the 2-qubit gate) [17]. The quantum circuit version allowed us to carry on measurements for an entangled witness in a neural network.

**Figure 4: Circuit Setup in Previous Paper**



The generalized idea of this project is to design a new version of the quantum circuit, starting with the circuit in Figure (5), for the diffuser portion of Grover's algorithm [18] also in terms of rotation gates. These gates will be converted to their exponential form to get an expression similar to (3c). Next, MATLAB [19] is used to find the values of KA, KB, εA, εB, and ζ. The following step is to formulate an expression for Equation (1a) with the constants and gates found. Up to this point, it is easy to see how this study is a backward version of [17]. The last two steps are to test whether H gives the desired output and then use Bootstrap on a larger system [20].

**Figure 5: Diffuser Portion of Grove's Algorithm**



The new circuit is constructed through the implementation of three gate identities: the rotation identities (Equation (4)), Hadamard gate identities

(Equation (5)), and a CNOT identity in terms of rotation matrices (Equation (6)) [15].

$$R_x(\theta) = e^{-i\theta X} = \begin{pmatrix} \cos\frac{\theta}{2} & -i\sin\frac{\theta}{2} \\ -i\sin\frac{\theta}{2} & \cos\frac{\theta}{2} \end{pmatrix} \quad (4a)$$

$$R_y(\theta) = e^{-i\theta Y} = \begin{pmatrix} \cos\frac{\theta}{2} & -\sin\frac{\theta}{2} \\ \sin\frac{\theta}{2} & \cos\frac{\theta}{2} \end{pmatrix} \quad (4b)$$

$$R_z(\theta) = e^{-i\theta Z} = \begin{pmatrix} e^{-i\theta} & 0 \\ 0 & e^{i\theta} \end{pmatrix} \quad (4c)$$

$$R_{xx}(\theta) = \exp(-i\frac{\theta}{2} X \otimes X) = \begin{pmatrix} \cos\frac{\theta}{2} & 0 & 0 & -i\sin\frac{\theta}{2} \\ 0 & \cos\frac{\theta}{2} & -i\sin\frac{\theta}{2} & 0 \\ 0 & -i\sin\frac{\theta}{2} & \cos\frac{\theta}{2} & 0 \\ -i\sin\frac{\theta}{2} & 0 & 0 & \cos\frac{\theta}{2} \end{pmatrix} \quad (4d)$$

$$H = R_y\left(\frac{-\pi}{2}\right) \cdot X \cdot R_y\left(\frac{\pi}{2}\right) \quad (5)$$

$$CNOT = e^{-i\frac{\pi}{4} R_{yA}(-\pi/2) R_{xA}(-\pi/2) R_{zAB}(-\pi/2) R_{zA}(\pi/2) R_{yA}(\pi/2)} \quad (6)$$

The goal of using these identities is to have a circuit in terms of rotation matrices only. Matrix manipulation is used under the precedent that any Pauli Matrix times itself is equal to the identity matrix [21] to dispose of some gates. Therefore, having a much smaller and simpler circuit to work with. Using the identities above (Equations (4-5)) for the first three gates in Figure 5 for |B> the following was obtained:

$$HXH = R_y\left(\frac{-\pi}{2}\right) X \cdot X \cdot XR_y\left(\frac{\pi}{2}\right)$$

where  $X \cdot X = I$ . Therefore, what is left is

$$HXH = R_y\left(\frac{-\pi}{2}\right) \cdot XR_y\left(\frac{\pi}{2}\right)$$

...and now doing matrix multiplication with the remaining 3 matrices:

$$\frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 1 \\ -1 & 1 \end{pmatrix} \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} = -iR_z(-\pi)$$

An overall phase of -i has been obtained. For measurement purposes, this is a global phase, and therefore, will not affect the outcome of the algorithm. A very similar operation can be done to the same |B> after the CNOT gate portion of the circuit. Therefore, instead of having 6 individual gates, they have been reduced to only 2. Something very similar happens to |A>; in both sides of the CNOT gate the 4 individual gates can be reduced to only 2 by doing the following:

$$XH = X \cdot XR_y\left(\frac{\pi}{2}\right)$$

where all is left is  $R_y(\pi/2)$ .

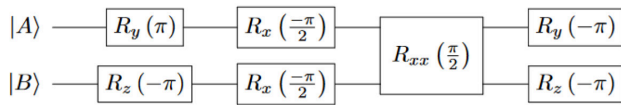


## Discussion

A picture of the reduced circuit is included in Figure 6. The four gates to the left of  $R_{xx}$  represent  $H_{A,1}$  and  $H_{B,1}$  respectively; they are the first-time chunk for the full Hamiltonian  $H$ .

$R_{xx}$  itself represents  $H_{AB,2}$ , the second-time chunk, and the last two gates represent  $H_{A,3}$  and  $H_{B,3}$  respectively.

**Figure 6: Reduced Circuit**



Next, the exponential form of the rotation gates from Equation (4) was used to transform the circuit into an expression of the form of Equation (1a). The result for the full Hamiltonian is shown in Equation (7). Each individual time chunk is defined in Equation (8). It is worth noting that for  $H_{A,1}$ , the result is an acceptable approximation because of the short  $\Delta t$  as gates and  $R_y$  and  $R_z$  do not commute. The full Hamiltonian is shown in Equation (9).

$$H = (H_{A,1} + H_{B,1}) + H_{AB,2} + (H_{A,3} + H_{B,3}) \quad (7)$$

$$H_{A,1} = \frac{\pi}{2}Y_A - \frac{\pi}{4}X_A \quad (8a)$$

$$H_{B,1} = -\left(\frac{\pi}{2}Z_B + \frac{\pi}{4}X_B\right) \quad (8b)$$

$$H_{AB,2} = \frac{\pi}{2}(X_A \otimes X_B) \quad (8c)$$

$$H_{A,3} = -\frac{\pi}{2}Y_A \quad (8d)$$

$$H_{B,3} = -\frac{\pi}{2}Z_B \quad (8e)$$

$$H = \left[\frac{\pi}{2}Y_A - \frac{\pi}{4}X_A - \left(\frac{\pi}{2}Z_B + \frac{\pi}{4}X_B\right)\right] + \frac{\pi}{2}(X_A \otimes X_B) - \left[\frac{\pi}{2}Y_A + \frac{\pi}{2}Z_B\right] \quad (9)$$

Gate manipulation is a useful way to create shorter circuits. For this project, it was possible to go from 7 columns of 11 different gates down to only 4 columns of 7 gates. This reduction of gates may not seem significant for the 2-qubit case, but the real advantage

will come for larger systems where circuits can be reduced by 30 or more gates. The following steps for this project include testing the Hamiltonian in Equation (9) in the MATLAB code with the appropriate mapping time of about 288ns. Once the desired results have been obtained, the next step is to use bootstrap from the 2-qubit system to a 3-qubit system and so on. At this final stage of the project, it will be possible to tell whether the algorithm can be sped up. Proving that certain quantum algorithms can be even further refined to show a greater amount of computational advantage confirms that our knowledge of quantum phenomena becomes more profound as research progresses in this field and more real-world problems are able to be solved.

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If I have seen further, it is by  
standing on the shoulders of  
**Giants.**

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*McNair Scholars Program*

**2022-2023**

Continuing the Legacy

# Research Summaries



# Estimating the Ultra-High Energy Neutrino Flux from the Accretion Disks in the Galactic Core at Earth

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## Introduction

The purpose of this research is to determine the ultra-high energy neutrino flux coming from the galactic core, Sagittarius A\* (Sgr A\*), and from the many other accretion disks within the galactic bulge at Earth. The direct galactic core neutrino flux is exceptionally low. Very few neutrinos from the galactic core are measured. We created two models to simulate the galactic core neutrino flux. The first, a simple linear simulation, relied on the properties of the accretion disks and Sgr A\*, which included the accretion disks' quantity, sizes, and distances. In the second, we replaced the linear accretion disk distribution with a more robust code that randomly distributed the accretion disks and generated bodies of varying sizes. This determined the ultra-high energy neutrino flux to be  $1.30563 \times 10^{-11} \text{cm}^{-2}\text{s}^{-1}$ . Since it is extremely hard to determine neutrino direction from their interactions, we envision an application of this flux where the energetic galactic core neutrinos are gravitationally focused by the Sun with a "light" collecting power of  $10^{11}$ – $10^{12}$ .

Located 25,800 light years away, a supermassive black hole (around 4 million times the mass of the Sun) named Sagittarius A\* (Sgr A\*) lies in the center of the Milky Way galaxy. Sgr A\* is one of the many sources of neutrino emission. Neutrinos are low-mass, weakly interacting particles that travel near the speed of light. Due to the high-energy environment, the primary neutrinos emitted are ultra-high energy from 10<sup>9</sup>–10<sup>18</sup> eV, i.e., GeV to EeV [1]. However, the neutrino flux of the galactic core is still unknown.

Accretion disks are circumstellar disks that consist mainly of the material from the object it is orbiting and are known to excrete a considerable amount of ultra-high energy particles including neutrinos [2]. Over time, as accretion disks accumulate more mass, it can change sizes and increase the number of particle interactions [3]. This results in the energy and temperature rising, which then accelerates the disk and advances the probability of energetic particles

produced from the high-energy interactions. If the energy of the particle is high enough, then particles can escape the disk; therefore, increasing the neutrino emissions. Supernova remnant, Messier 1, also known as the Crab Nebula, is one of the most studied objects in space. Within the initial attempts of this study, this supernova remnant was treated as a standard candle. All accretion disks in the model were the exact size of the Crab Nebula, and were used as a reference distance to scale the disks to find our galactic core emission estimate.

This research attempts to determine the overall flux of ultra-high energy neutrinos produced by the galactic core and the accretion disks within the galactic core. Estimating the flux will provide a general approximation of the number of ultra-high energy neutrinos that should reach Earth, with Earth being the overall detector. Moreover, studying neutrinos will provide more information on the conditions of the galactic region and allow characterizations of it to be formed.

## Methods

Using MATLAB, a model was created consisting of a simple linear distribution simulation that relied on the quantity, sizes, and distances of the accretion disks and Sgr A\*. To formulate the model, the Crab Nebula was used as a standard candle reference for all accretion disks within the galactic core. The distance from the Earth to the nebula is about 2 kpc, and the Crab Nebula's flux is measured to be  $8 \cdot 10^{-15} \text{cm}^{-2} \text{s}^{-1}$  [9]. Assuming that there are 5,400 accretions disks in the galactic core that are the same size as the Crab Nebula, they were placed in a straight line that was logarithmically spaced over the distance of the galactic region, which is 2-3 kpc [4, 5, 6]. The disks will be closer together towards the center of Sgr. A\* and gradually get further from one other as it nears the edges of the core.

Accordingly, the distances of each accretion disk from the galactic core to Earth were determined through Pythagorean Theorem. Scaling the distance from each disk to the Crab Nebula provided an estimate of the flux from each accretion disk. The total sum was found by using the equation below.

$$\phi_{AD} = 2 \sum \frac{\phi_{CN}}{d_{scaledCN}} \quad (1)$$

We repeated the same method to determine neutrino flux coming from Sgr A\* with the known galactic core flux of  $1.4287 \cdot 10^{-16} \text{cm}^{-2} \text{s}^{-1}$  [8] at the distance of 25,800ly and scaling it to correct for the proper reduction in signal. Adding the summations together, and doubling them due to symmetry, provided the total flux for this simulation. However, to estimate the neutrino flux more accurately, the linear accretion disk distribution was replaced with a more robust code.

Rewriting the foundation of the linear code in C++ allows for the randomization of the accretion disk placements and sizes. With the previously assumed number of 5,400 accretion disks, each disk had a random generation of 3-dimensional Cartesian coordinates within the galactic core. The clustering of disks closer to Sgr A\* and the sparseness as the disks were further away from the center remained the same. Secondly, the accretion disks sizes were randomized from a lower limit of 0 light days to an upper limit of 10 light days (about  $8.3943 \cdot 10^{-6} \text{kpc}$ ) [10]. Having gathered the randomized coordinates of each accretion disk and assuming  $x_0 = y_0 = z_0 = 0$  are the Earth's coordinates, the distances from Earth to the disks were able to be calculated using the third-dimensional distance formula. All the distances to each disk were then scaled to the distance of the Crab Nebula. Next, the ratio was multiplied by the Crab Nebula's neutrino flux ( $8 \cdot 10^{-15} \text{cm}^{-2} \text{s}^{-1}$ ), which approximated the flux for all the disks in terms of distance. Due to the Crab pulsar (the star in the center of the Crab Nebula) being relatively young, it was assumed that the



accretion disk would be around 3 light days. Scaling the randomized accretion disks radius to the assumed radius of the pulsar and multiplying it by the CN's flux provided another approximation of the flux in terms of radius. By taking the average of the flux in terms of distance and radius of all 5,400 ADs, the estimated ultra-high energy neutrino flux was determined.

## Results

The linear simulation provided a preliminary neutrino flux of the galactic core and showed that the probability of ultra-high energy neutrinos reaching Earth is scarce. This result does not incorporate any form of special relativity but is simply the flux of the galactic core if no object or phenomenon was between it and the Earth.

By randomizing the accretion disk placements and sizes, the simulation became a reasonable model of the galactic core. Through all the calculations, it was determined that the ultra-high energy neutrino flux is:  $1.30563 \times 10^{-11} \text{cm}^{-2}\text{s}^{-1}$ . Neutrinos from active galactic nuclei (AGN) have a vast amount of energy due to the high energy conditions they are born in. Although, the flux is exceptionally low with ranges of  $10^{-16} - 10^{-28} \text{cm}^{-2}\text{s}^{-1}\text{sr}^{-1}\text{MeV}^{-1}$  [2]. The preliminary flux determined using the randomized model is off by five orders of magnitude. There are several reasons to explain why the real value is lower than the estimate here:

1. The neutrino flux from or the distance to the Crab Nebula source used here as a standard candle is wrong. But our estimate can be scaled by using an improved Crab Nebula number or another standard source.
2. There are far fewer accretion disks in the galactic core than currently expected.
3. The accretion disks randomly distributed were assumed to be identical to the Crab Nebula source and a flat distribution of different sized sources

each equally possible scaled. More likely, larger accretion disks are exponentially rarer than smaller ones, with these smaller disks producing less and lower energy neutrinos which would need to be entered into the simulation and recalculated.

4. Neutrino propagation to the Earth is assumed to be unaffected by matter. But if more stars, neutron stars, black holes, or dark matter could interact and stop neutrinos than expected, then this has not been considered for our simple estimation. These effects could be an exciting application of this idea to study the space over which the neutrino propagates from the Galactic Core to Earth.

## Conclusion

Studying the ultra-high neutrinos from the galactic core will inform researchers of the probability of detecting them, and allow an expanse of knowledge about the characteristics of Sgr A\* and the environment around it. Neutrinos rarely interact with ordinary matter, therefore, if a galactic neutrino is detected, its properties will be similar to how it was within the galactic region. Additionally, due to their low mass, neutrinos always travel near the speed of light, which will provide a relatively recent analysis of the activities occurring in the center of the galaxy.

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# From Last to First: Elevating the First-Generation Student Experience

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## Introduction

First-Generation college students (FGCS) make up fifty-six percent of the undergraduate student population in the United States (Hamilton & Freeman, 2023). FGCS may have high difficulty in transition, feelings of imposter syndrome, and elevated levels of stress and uncertainty surrounding their college experience (Gist-Mackey). Despite their majority, FGCS are one of the more underserved groups on college campuses and in universities, struggling with “lower degree completion rates, higher student loan debt, and a lack of support for first-generation students of color” (Markle, 2020). They are also less likely to be academically prepared and more likely to lack a sense of community and engage in paid labor while attending school (First Generation Foundation, 2013; Gist-Mackey, 2018).

This study’s intent is to analyze the effectiveness of first-generation initiatives to inform efforts at Wichita State University to create new and effective programming and resources for first-generation college students.

## Methods

An extended literature review was conducted to investigate previously researched programs and resources available to first-generation students within an academic environment. Peer-reviewed articles that focused on formal academic initiatives for FGCS were selected.

Further exploration was conducted through outreach to college/university first-generation Programs within the United States. These universities were chosen according to geographic location, demographic makeup, and status as peer institutions or aspirational institutions for Wichita State University. Further, several of the universities chosen are known as First Forward Institutions.

After careful evaluation, the schools chosen for review include Kansas State University, the University of Missouri in Kansas City (UMKC), Texas A&M, Missouri State University, Texas Southern University, Purdue

University, the University of Arkansas, Georgia State University, and Memphis. The initial review began on each of the university's public websites to gain the perspective of a prospective student searching for what first-generation resources are available to students on campus. Further outreach was conducted via an email interview. A series of questions was formulated focusing on the types of programs available to students, formalized first-generation student centers, success and usage rates of these programs, scalability, and awareness that these programs exist. These questions are listed below.

1. What resources does your school offer for First-Generation College Students?
2. Does your school offer a physical space or a designated student center for first-generation college students?
  - If so, what services does that space/center offer?
  - What services are most utilized by students?
3. What methods have you found useful for creating awareness that these programs and services exist?

Several respondents provided reference to their respective school's website, so further exploration of the school website was conducted after the interview to fill gaps in knowledge.

## Literature Review Findings

Several relevant themes and topics arose from previous research for methods to assist FGCS throughout their transition and adjustment to college. These include social involvement, having a physical safe space, early intervention and education, and financial aid.

Social support and involvement were the most prevalent within the literature. It is commonly accepted that FGCS often lack a significant sense of community during their undergraduate careers (Gist-Mackey,

2018). The most common form of support available to students is informational support, which requires a person or a place to reference helpful information about the college experience and ask for advice. Other types of support include emotional support, appraisal, and instrumental support, which are tangibles such as time, money, or physical assistance. The social support that prioritizes the inclusion of all four types provides the highest chance of retention and undergraduate success for FGCS and is often provided in the form of mentorship. However, while specialized mentoring programs are shown to be effective, they "are challenging to scale up to engage the majority of students who need support" (Fruht, 2018).

Another effective method of elevating first-generation college students is through the creation of a physical safe space. One study conducted by Sarah Roberts and Krista Lucas explored a Title V center as a counterspace for underrepresented minority and FGCS. These counterspaces serve as a safe space that creates a positive collegiate climate for the groups facing these microaggressions in academic and social spaces (Roberts & Lucas, 2020). Physical centers create a safe space for students to feel comfortable going to receive support (Roberts & Lucas, 2020).

The last key theme is early intervention and education. Markle and Stelzriede found that FGCS reported lower levels of confidence in their ease of transition and perceived themselves to be less academically prepared compared to their continuing-generation peers (Markle & Stelzriede, 2020). Because of this, a standard approach by many colleges and universities is to offer a summer bridge program. These often showcase academic advice and strategies (Stephens, 2014). Many of these programs teach a student what they may be lacking coming into the semester that continuing-education students, or students with at least one parent with a college degree, have.





Deficit thinking is person-centered and characterizes first-generation college students as needing to be “fixed” rather than focusing on ways to make the educational system more inclusive (Valencia, 1997). To combat this, many researchers are adopting an anti-deficit/asset-based framework for studying first-generation students (Martin, 2020). Anti-deficit, or asset-based thinking, focuses on the concept of social capital: the resources gained through relationships. It “treats an individual’s social relationships as inherent assets (Martin, 2020).” Martin and team found that focusing on asset-based thinking instead of deficit-based thinking provides insight into a few ways that the “educational system can be altered to promote the success of all students by leveraging the strengths of their existing social networks, providing additional unambiguous paths to forming new network connections. (Martin, 2020).”

## Interview Findings

Sixteen individuals representing the selected schools were identified as a contact for FGCS programming. Three individuals responded. Each represented a FIRST-Forward Institution, the University of Missouri at Kansas City (UMKC), Kansas State University, and Texas A&M University.

K-State reported that celebration events are the most utilized service/resource, while peer mentoring is the most utilized service/resource at UMKC. Additionally, UMKC reported significant GPA gains for students who participated in their First Gen Roo program. Students who successfully completed the program earned an average 3.31 GPA compared to a 2.93 for FGCS who did not participate.

Each of the universities found word of mouth to be one of the most useful methods for creating awareness about programs and services. Other than word of mouth, monthly emails, text messaging platforms,

and social media such as Instagram have shown to be effective at spreading the word as well. High school and college counselors help notify prospective students of programs as well.

## Comparison Findings

Upon further investigation of each school’s resources, the following information was found: TRIO Student Support Services or TRIO McNair are present at all institutions, except UMKC. Additionally, celebration events are offered at 5 of the 9 universities (U of M, MSU, TSU, Purdue, K-State). Table 1 provides a comparison of the other services offered at each institution.

**Table 1: Services Provided by Selected Universities**

Services/ Institutions	Targeted Programming	Student Org/ Honor Society	Other
U of M	First Scholars Program (with \$20,000 in scholarship funding)	FGCO Organization	Peer Mentoring
MSU	N/A	FGCO Organization	First-Generation Student Success Advisory Council, and Scholarships
TSU	N/A	N/A	Scholarships
Purdue	N/A	FGCO Organization	Scholarships
K-State	Workshops	Honor Society	Tutoring and Coaching
U of A	FG Mentoring Program, and 360 Program: Participation by Invitation Only, No Referrals allowed	N/A	First-Gen Zoom Backgrounds
UMKC	Peer Mentoring **	N/A	Tutoring, Writing Studio & SI
Texas A&M	New Student Conferences	FGCO Organization	Regents’ Scholars Program - Scholarship, and Math Learning Center
GSU	N/A	N/A	Website Guide for Transition into First Year of Undergraduate

The purpose of this study was to conduct an extensive review of services offered through first-generation success centers at four-year colleges and universities. This helps to build an understanding of improvement efforts for retention and graduation rates of first-generation students at Wichita State University. Throughout the course of the literature, it has become apparent that providing a combination of social involvement, a physical safe space, early intervention and education, and financial aid are instrumental in improving the success of FGCS in the universities described within. To improve retention rates and the overall performance of FGCS at Wichita State University, a combination of these should be offered on WSU’s campus.

Currently, Wichita State University offers a summer bridge program, "Passage 2 Success", as well as a first-generation peer mentoring program titled the "Spirit Strong First-Generation Scholars" Program. However, these programs are only available for a fixed number of students and are difficult to scale up to meet the needs of all of the students who need assistance. Wichita State does not have a designated office to serve FGCS. A physical office makes informational, instrumental, and emotional support much more accessible.

Other methods of elevating FGCS on WSU's campus may include adopting an asset-based framework of thinking during summer bridge programming, holding orientation events specifically for FGCS, holding social events with first-generation professors, and expanding mentorship programs for this group of students.

Future studies should include interviews conducted with Wichita State University FGCS to deeply understand the most common struggles of students in Wichita. During a review of the literature, there was also a lack of representation from the perspective of professors and administrators in their struggles for supporting FGCS. Therefore, interviewing professors and administrators could provide a perspective on how best to implement programs that students are so desperately in need of. Most importantly, because some FGCS do not properly feel prioritized by some of the initiatives advertised to serve them and instead report feeling as though their respective university is attempting to reach a quota, WSU must make an effort to be sure that their prioritizing and future elevations of FGCS (and any other marginalized group) are from a place of sincerity, making sure to always consider student voices and circumstances (Shook, 2019).

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# Temperature's Effect on Microcosm Community Abundances

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## Introduction

Freshwater microbes can tolerate a wide variety of environmental conditions. Many have evolved strategies to cope with stressors. Drought is a significant stressor that can alter the structure of microbial community populations. Microbes have developed adaptations including burrowing or migrating to reach more optimal conditions, dormancy to wait until conditions improve, and desiccation tolerance to regulate water content. Some zooplankton can quickly reproduce before drying events, which could allow offspring to survive the conditions as non-developing eggs until optimal conditions return, or development may begin, then pause through diapause.

Changes in the structure of these populations can have cascading effects on the local food web, affecting amphibians that rely on plankton as a food source. Species can go locally extinct due to these structural changes that could favor organisms better adapted to drought conditions (Philippot 2007, Weinbauer &

Rassoulzadegan 2007). These shifts in populations can be short or long-lasting when migration through other systems or attachment dispersal is limited. These aquatic systems have been found to have higher community compositional turnover than compared to soil. This could mean that these populations are highly adaptable after disturbances (Shade et al. 2013).

When a dried pond is rewet, this triggers the microorganisms to reactivate. The dissolved organic compounds increase sharply, providing nutrients for rapid growth. Some organisms may quickly reproduce and then become the food for larger and later developing zooplankton. As the cycle continues, the community dynamics may constantly fluctuate, with different types of organisms growing in abundance.

The temperature of the environment strongly affects microbial activity and varies by species. For every 10°C above 5°C, the activity increases to a limit of 40°C,

where it begins to decrease as temperatures increase to 65°C where proteins denature. Despite increased activity, higher temperatures can lead to negative consequences for some due to increased predation. This occurs as metabolisms develop higher demands, tolerating an above optimal temperature range. Other microbes reproduction is triggered by warmer temperatures, possibly increasing their survival rate.

How the temperature affects the microbial community response after rewetting is not deeply studied. Previous studies have focused strongly on soil bacteria and fungi, not on the water column zooplankton and invertebrates (Bonacina et al. 2023, Khan et al. 2019, Sieblec et al. 2020, Stres et al. 2008).

## Methods

In this study, we consider how microbes respond in microcosms of soil from an ephemeral pond being rewet in spring after extreme drought at five temperatures. These temperatures ranged from 16°C to 32°C at 4°C intervals in Percival environmental chambers on a 12:12 light/dark cycle, with each treatment replicated four times and sampled twice a week for eight weeks. Twenty microcosms were created by coring soil from Bullfrog Pond at Wichita State University's Biological Field Station, Ninnescah Reserve. They were filled with approximately 250 ml of rainwater to saturate the soil before having 500 ml of rainwater fill the tube above the soil line. At sampling, 10 ml of water collected from the tube was filtered through 1000  $\mu\text{m}$  and 600  $\mu\text{m}$  nylon strainers before imaging through the FlowCam 8100 (Yokogawa) with the 4x lens and 600  $\mu\text{m}$  FOV flow cell. Afterward, images were categorized based on their phylum to genus when possible.

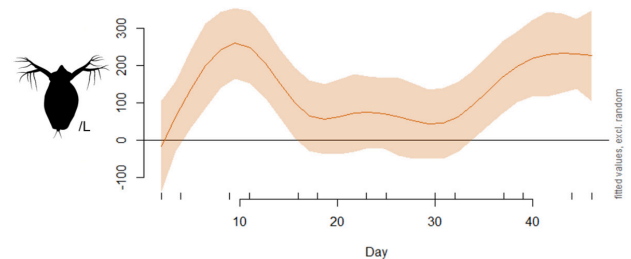
## Findings

These preliminary results reflect observation over 7 of the 8 weeks. Rotifers were the most abundant phylum.

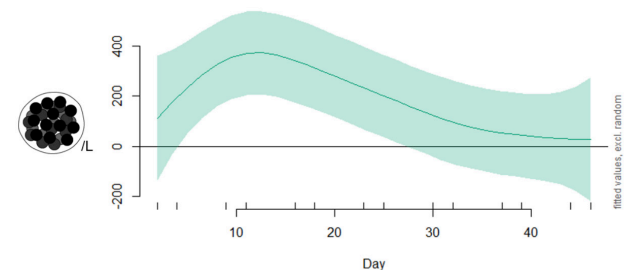
Arthropods, namely *Daphnia* and *Leptostheria*, were the second most common. Chlorophyta was the third most abundant, but not well identified, except for a few genera including *Pediastrum* and *Eudorina*. Ciliates were the fourth in abundance, with *Hypotrichs* the most imaged out of the ciliates. Some groups, such as euglenoids, were pictured too infrequently to track.

Using a generalized additive model (GAM), we were able to look at the observations with smoother terms based on the day of appearance and the day by temperature. We found significant effects on Arthropods, Chlorophyta, and Rotifera.

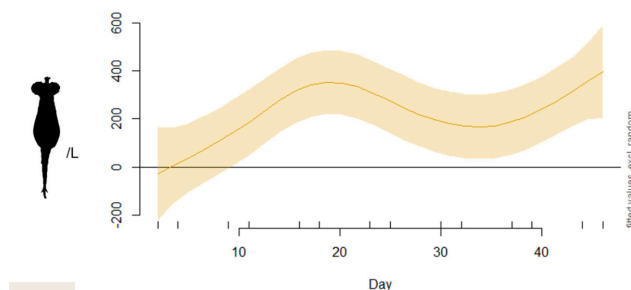
**Model A: This shows the estimated concentration of Arthropods per L on the Y-axis, over time in days on the X-axis.**



**Model B: This shows the estimated concentration of Chlorophyta per L on the Y-axis, over time in days on the X-axis.**



**Model C: This shows the estimated concentration of Rotifers per L on the Y-axis, over time in days on the X-axis.**



## Discussion

Our results suggest that there is a strong effect on Arthropoda from rewetting on the abundance of these in time ( $p$ -value 0.00013) and at what temperature ( $p$ -value 0.001722) treatment the arthropods were at. This is likely due to diapause as a mechanism for repopulation. Previous research indicates these genera have a range of thermal optima (Seefeldt & Ebert 2019, Taldi et al. 2021). This aligns with our observation of increased abundance at a higher temperature.

Chlorophyta was not as affected by the date after rewetting; instead, the results suggest temperature ( $p$ -value 0.0163) is a more significant factor for the phylum with lower abundances observed at the higher temperatures. This may be contradictory to previous studies indicating that algae blooms are connected to increased temperatures. However, this is likely a species-specific effect or due to the microalgae being beyond its optimal temperature (Rautenberger & Bischof 2006).

Conversely, rotifers were affected through the date by temperature ( $p$ -value 0.00257) and appeared to favor higher temperatures. This likely would have a strong effect on their abundance. Lower temperatures have been shown to extend their juvenile period, while higher temperatures shorten their lifespan (Yona 2018).

## Summary

Rotifer and Arthropod abundances appeared to be positively affected by higher temperatures, while Chlorophyta was negatively affected. This may indicate what could occur when an ephemeral pond refills across a range of temperatures. If the pond is refilled later in the year, Chlorophyta may be unable to stabilize the population. This would negatively impact the trophic web dependent upon the pond for refugia from fish such as amphibians using the site for egg-

laying. At higher temperatures, rotifers and arthropods may cycle in abundance during the first two months. This could show how they can survive through drought periods as they rapidly repopulate.

## Future Research

Results are still undergoing QA/QC. Our next steps are to finish assessing the final 40 flow-cam runs from the eighth week, then we will add them to our data set and further analyze the results with R. This project also ran samples through a higher magnification lens, 10x with 100um FOV, and has 320 runs to assess and determine what further information can be gained from this study. It may provide a window into the repopulation success of these phyla when compared to the results of the higher sizes viewed through the 4x lens.

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# Assessment of the Boxed Springs (41UR30) Ceramic Assemblage

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## Introduction

Around 2,500 years ago during the Woodland period in the region that is now east Texas, ceramics were first produced by the Fourche Maline culture or pre-Caddo and showed similarities to wares being produced in the Lower Mississippi Valley (Perttula et. al 1995:177; Perttula et. al 2021:116). The earliest vessels manufactured during this period are characterized by their tempering materials which included plain-grog and bone tempers. By A.D. 800, rapid transitions in the approach to how vessels were produced and decorated occurred in the region marking the emergence of the Early Caddo period (Story 1990:247; Perttula et. al 1995:177; Early 2012:26; Girard et. al 2021:19). These new traditions coincided with changes in mortuary practices, ultimately increasing the need for pottery as they began placing them in burials.

### Ceramic Wares in East Texas

Ancestral Caddo ceramics are characterized by three ware types: plain, fine, and utility wares. Each type

of ware is defined by a set of basic vessel forms that include bowls, bottles, jars, and carinated bowls (Perttula 2021:119). Forms produced in the east Texas region are often homogenous across each ware type, however, these shapes would have been recognizable to other contemporaneous Caddo communities because vessel shapes are regionally distinctive (La Vere 1998:92; Perttula 2013:184; Perttula 2021:120). Ceramic vessels can be an integral aspect in the analysis of lifeways, especially that of the ancestral Caddo because each vessel has been found in different contexts. Plain wares, for instance, have primarily been found in domestic contexts which suggests that their primary function is related to foodways. Utility wares are also found in domestic contexts regarding beverages, cooking, as personal possessions, or food storage (Perttula 1995:177). Fine wares are commonly found in both domestic and mortuary contexts, however, they are thinner vessels with finer tempers, paste, and surface treatments (Perttula 2021:122).

## Previous Investigations at Boxed Springs (41UR30)

Situated on an upland formation upstream from the confluence of the Sabine River and Big Sandy Creek in eastern Texas, Boxed Springs (41UR30) was first identified in the early 1960s by avocational archaeologists Sam Whiteside and Norman Bedgood (Perttula 2011:2). The initial investigations at the site documented four earthen mounds (Mounds A-D) which were used for various purposes both secular and sacred. Following these investigations, Dee Ann Story mapped it in 1982, adding the newly constructed metal farm building as a landmark (Perttula 2011:16). After later excavations on behalf of UNT in 1988, it is important to state that Boxed Springs (41UR30) suffered extensive looting at the Early Caddo (ca. A.D. 800-1200) cemetery located in the northern field (Perttula 2011:16). The cemetery at the site is noted to be located away from the mounds, and approximately 150 burials were disturbed (Perttula 2011:16). In 1990, Dr. Timothy K. Perttula and Dr. James E. Bruseth were given the opportunity to document a large collection of artifacts from the cemetery (Perttula 2011:17). Of these artifacts, 160 vessels were recorded with fine wares accounting for 44% of the funerary objects. Plain wares accounted for 35% of the funerary assemblage, and utility wares comprised the remaining 20% of associated funerary objects.

Permission was again granted in 2010 by the landowners to investigate Boxed Springs with the intention of gaining insight into the archaeological and archaeogeophysical contexts of the Early Caddo occupation at the site (Perttula 2011:19). The research conducted at this site was not funded by external sources, limiting the scope of the investigations. As such, the site was approached as an “incremental and long-term process” (Perttula 2011:19). Compared to other Early Caddo mound centers in the region, Boxed Springs is lesser-known, which is why the analysis

of the site was critical to not only understanding previous occupations but also their relation to other contemporaneous communities and the landscapes in which they lived. These investigations sought to form a better understanding of the spatial scale of the ancestral Caddo that inhabited Boxed Springs (Perttula 2011:19).

## Current Investigations

Over the past four years, Wichita State University has been given permission by the new landowners to research the eastern portion of the Boxed Springs site (41UR30). The initial investigations conducted by Wichita State University in 2019 sought to identify and assess the condition of two proposed mounds at the site and to determine artifact recovery (Haley and Dozier 2020:78). Following the COVID-19 pandemic, Wichita State University returned to Boxed Springs in 2021 to continue archaeological investigations at the site. Results from that investigation have shown that some areas of the site are affected by modern targets, whereas others are affected by the overlapping of habitation areas (Haley 2022:22). Nonetheless, the survey identified five possible structures and found anomalies that are consistent with occupation areas (Haley 2022:22). In the spring of 2022, Wichita State University returned and recovered radiocarbon samples and artifacts from the duration of the 2021 and 2022 investigations, providing data related to the temporal placement of the ancestral Caddo inhabitants at Boxed Springs. One of the primary goals of the investigations conducted by Wichita State University is to identify the locations of both Mounds B and D to avoid disturbing them.

## Boxed Springs Ceramic Assemblage

The ceramic assemblage from Boxed Springs is defined by a markedly diverse and expansive set of plain wares,



fine wares, and utility wares. Of these wares, the most common tempering materials included grog (fired clay or crushed sherds), bone (burned and crushed), and hematite or ferruginous sandstone (Perttula 2011:62). Additionally, it is evident that firing conditions at the site varied greatly based on previous analyses of cross-sections and core identification (Perttula et. al 2021:12; Perttula 2013:204; Perttula 2011:48). Firing conditions were likely based on the potter's personal preference, what type of clay they were using, the desired outcome, and what function it would serve (Perttula 2021:12).

Ceramic typologies use the analysis of decorations, motifs, patterns, and elements on vessels to aid in identifying the chronological sequence of sites because ceramics change more rapidly over time than other forms of material culture. Fourteen typologies have been identified in the Formative to Early Caddo Period (A.D. 850-1200) in the east Texas locality. Of these fourteen types, only twelve have been previously identified at Boxed Springs. The analysis of plain to decorated sherds ratio (P/DR) has also been useful in identifying the temporal placement of sites because earlier Caddo sites have lower ratios than later sites as the production of decorated vessels increased over time (Perttula 2011:52).

## Methods

The ceramic assemblage (n=254) recovered from Boxed Springs was assessed for eight attributes: vessel form, decoration, temper, thickness (mm), interior and exterior surface treatment, firing conditions, and ware type. Sherds were then compared to previously identified Early Caddo ceramic assemblages in the east Texas locality (Perttula 2011:18, 48-77; Perttula 2015:36-43; Perttula 2016:26; Perttula 2021:126). To facilitate the analysis of tempering materials, a Bausch & Lomb Microscope with 0.7x-3x magnification was used. Imaging was done with a Leica DM750P

microscope at magnifications ranging from 5x to 50x when deemed necessary. Measurements were also taken using digital calipers to record vessel thickness to aid in the identification of typology and ware type. Sherds were also assessed for firing atmospheres by analyzing the cross-sections and comparing them to a firing conditions model first defined by Teltser (1993).

## Results

Of the total ceramic assemblage recovered by Wichita State University (n=254), 201 sherds were sampled for this study, as they most accurately represent the temporal placement of the site and its provenience. The ratio of plain sherds (n=156) to decorated sherds (n=45) produces a P/DR of 3.46, which is slightly lower than previous findings (Perttula 2011:281). The identified tempers (n=21) from Boxed Springs show that the ancestral Caddo who occupied this site had an array of materials available to them to produce their pots. However, it is evident that there was a material preference that included grog, bone, and ferruginous sandstone solely, in combination with each other, or in combination with other aplastic materials. These findings are consistent with previous investigations and the different types of pots available at the site. Eleven typologies were identified in this study and are consistent with vessels from the Formative to Early Caddo Period (A.D. 800-1200). Additionally, the minimum number of vessels (MNV) is 32.

## Discussion

The assessment of Boxed Springs ceramic assemblage recovered by Wichita State University is thus far consistent with previous analyses of the site (Perttula 2011). Not only do these findings show the significant range of choices available to ancestral Caddo potters, but it also shows the multifaceted way in which ceramics permeated Early Caddo lifeways.

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# #TeApoyamos: Preventing Suicide Spanish Training Efficacy Study

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## Introduction

According to the US Department of Health and Human Services (2020), suicide was the second leading cause of death in Hispanics ages 15 to 34 in 2019. "Recognition and referral" trainings are part of selective prevention strategies, also known as gatekeeper trainings. They provide knowledge on how to identify and assist those who are at risk for suicidal behavior (Hawley et al., 2022). The purpose of this study is to determine the effectiveness of the #WeSupportU Preventing Suicide Training when translated into Spanish. It has been implemented at Wichita State University in English and has shown effectiveness in terms of increasing suicide prevention knowledge, awareness, and intention (Hawley et al., 2022). We expect the Spanish version to achieve a similar result for Spanish-speaking communities.

According to the World Health Organization (WHO), over 800,000 people die by suicide a year (Preventing suicide: a global imperative, page 2, 2014). When

it comes to death by suicide, there is no single explanation; rather, there are many factors that contribute to leading a person to make that decision. Some of these risk factors are at the individual level, and others are at the community or relationship level. Factors at the individual level that increase a person's vulnerability to suicidal behavior are previous suicide attempts, mental disorders, excessive alcohol/drug use, financial loss, and chronic pain (Preventing suicide: a global imperative, 2014). Factors at the community and relationship level include war and disaster, stresses of being displaced, discrimination, sense of isolation, abuse, and violent relationships (Preventing suicide: a global imperative, 2014). Considering these factors, it is imperative to understand that some factors affect populations disproportionately. For example, in countries where war and violence are prevalent, suicide could be increased by these risk factors.

According to the US Department of Health and Human

Services, suicide was the second leading cause of death in Hispanics ages 15 to 34 in 2019 (Mental and Behavioral Health - Hispanics - The Office of Minority Health). Major factors that contribute to the risk of suicide for the Hispanic population are experiences of prejudice and discrimination, a combination of sociodemographic and cultural determinants, and mental health problems (Khubchandani & Price, 2022). According to the US Department of Justice, Hispanics experience a higher rate of violent hate crime than non-Hispanic whites, 1.3 per 1000 and .7 per 1000 respectively (Masucci & Langton, 2017). The elevated level of violent hate crimes towards Hispanics is indicative of prejudice and discrimination, a factor that leads to a higher risk of suicidal thoughts and behavior.

As for mental health challenges, Hispanic communities show vulnerability to mental illness like the general population but experience disparities to access and quality of treatment (Hispanic/Latinx). These disparities come from poverty, a lack of cultural competency from providers, and a negative mental health stigma in Hispanic communities (Hispanic/Latinx). Some of these risk factors are more prominent because of the sociodemographic and cultural factors that affect Hispanics disproportionately. Sociodemographic and cultural factors are important social determinants of health; it is said that the zip code in which a person lives says more about their health than their DNA (Graham, 2016). Alleviating these risk factors would allow for better prevention of suicidal thoughts and behaviors, specifically in the Hispanic community. A key to suicide prevention is ensuring that individuals who are at risk of suicidal thoughts and behaviors have timely access to resources and interventions (Comprehensive Approach to Suicide Prevention 2020).

## Methods

To start an evaluative process, a request was completed and approved by the university's Internal Review

Board (IRB). In this study, the "Suspenders4Hope #WSUWeSupportU Preventing Suicide Training" was professionally translated into Spanish. The training topics included recognizing warning signs, risk factors, and statistics; intervention practices; and crisis resources (Hawley et al., 2022). It is a 90-minute recognition and referral (gatekeeper) training with the aim of improving awareness, knowledge, and intervention and delivering it in a trauma-informed way (Hawgood et al., 2021).

Study participants were recruited to attend the Spanish version of the training through announcements and advertisements sent to organizations within the Wichita community, particularly those with Spanish speaking clientele. No prior registration was required to attend. All interested participants who spoke Spanish were able to attend the training. Twenty-one participants were included in this training; five had completed suicide prevention training before.

Following the training, participants filled out a retrospective pretest-posttest survey about the training in Spanish primarily via Qualtrics. A hard copy was provided upon request and then uploaded to Qualtrics. The questionnaire was translated to Spanish based on 6 objectives that measure knowledge, awareness, and intention used with the English version of the training. Participants were asked to "Rate how much you agree: I know the signs and symptoms that indicate someone may be struggling with suicidal thoughts."

The following questions were analyzed for this study along with their objectives from "University Outreach for Suicide Prevention":

1. How aware are you of resources for those struggling with suicidal thoughts or feelings? (AWARENESS 1)
2. How willing would you be to intervene if you came in contact with someone you knew who was considering suicide? (INTENTION 1)



3. Rate how much you agree: If someone was struggling with suicidal thoughts, I think I would say or do something to try to help. (INTENTION 2)
4. Rate how much you agree: If someone were struggling with suicidal thoughts or feelings, I know about resources I could connect them to. (AWARENESS 2)
5. Questions were rated by the participants on a Likert-type scale from 0 to 10, 0 meaning "not at all" and 10 meaning "very" (Hawley et al., 2022).
6. Once the responses were gathered, a statistical analysis using a paired t-test was done to measure the difference of pre and post for these four questions of the questionnaire.

## Results

The null hypothesis for this study proposes that there will be no difference between participants' perceptions of their knowledge before and after the training. No statistically significant difference was found for questions 1, 2, and 4; therefore, the null hypothesis could not be rejected.

Individuals with previous training experience showed statistically significant change when comparing before and after averages for the 4 questions answered. Because the critical t-value fell within the 95% confidence interval, the null hypothesis was rejected, meaning there was a statistically significant change in the before and after questions average for the participants who have had previous training. However, there was not a statistically significant change for participants with no previous training.

Through open-ended questions, participants gave direct, qualitative feedback on the training. The data was quite limited since this is a pilot study; therefore, qualitative data was not coded. As the study continues and more participants take the training and give feedback, qualitative coding will be implemented.

Overall, one item showed a statistically significant change: "Rate how much you agree: If someone was struggling with suicidal thoughts, I think I would say or do something to try to help."

## Discussion

In this study, the participant's answers to the before and after questions of the #WeSupportU Suicide Prevention Training survey were run through a statistical analysis to assess the efficiency of the training when translated into Spanish. There was no statistically significant change in the participants that did not have training. When looking at the responses overall, there was a statistically significant change in the before and after answers in question 3, where the participants rated how comfortable they would feel to intervene if someone were struggling with suicidal thoughts.

It is crucial to incorporate the feedback given by the participants in future training courses to improve this training. Next steps for this study include recruiting more participants, specifically, those who have not had suicide prevention training before. The preliminary results from the analysis indicate a need to improve suicide prevention training through content delivery.

## Limitations

The limitations encountered in this study were the number of surveys completed. Although the G-factor was 50, there were only about 20 usable responses. Because this is a pilot study, the number of responses was satisfactory enough to start off with but not enough to run a statistical analysis. To do qualitative coding of the short answer questions on the survey, more responses would be needed for further analysis. The future goal is to compare the results of this study to those of the English version to determine the efficacy of the #WeSupportU Suicide Prevention training in Spanish.

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If I have seen further, it is by  
standing on the shoulders of  
**Giants.**

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# **Extended Literature Review Summaries**





# The Effectiveness of Public Transportation and School Busing Programs on Student Absenteeism

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## Introduction

Absenteeism is a unique problem facing many United States schools today. Attendance is necessary for students to be successful in school (Gottfried, 2017 p. 573). Absenteeism is due to a variety of factors. One often overlooked cause is the ability of students to get to and from school (Gottfried et al., 2021b). In many cities, vehicles are a necessity to be an active participant in society. Without a vehicle, transportation can quickly become an issue that prevents students from attending school. Public transportation, and transportation provided by school districts, is an important method of travel for students. Research into public busing and the reduction of chronic absenteeism is still relatively new territory. Current literature about absenteeism has focused on a variety of solutions with limited research into the effect public transportation has on student attendance (Gottfried et al., 2021b). Current literature has also documented other concerns with school and public busing systems that hinder the success of such programs (Munoz &

Sandoval, 2022, p. 556). Further research is needed to understand whether the availability of free public transportation increases attendance rates in suburban and rural school districts, as well as the efficacy of such programs.

The purpose of this literature review is to understand whether fare-free public transportation systems could reduce student absenteeism in K-12. Fare-free public transportation systems are programs that allow students attending a school district to utilize their community's public transportation system for free to allow them to access any stop on the route. This systematic review sought to exclude articles that were older than 15 years at the time of writing. An exception was made for an article published in 2006, which is one of the first articles to be published that discusses the research topic (McDonald, 2006). Only journal articles were included in the literature review. Masters' theses and other research publications such districts whereas

briefs by organizations were excluded. Databases searched include Google Scholar and the Wichita State University research database. Keywords used to search for literature include “student absenteeism,” “busing use AND reduction in absenteeism,” “public transportation AND student absenteeism.”

To understand the effect that the availability of free public transportation has on absenteeism rates, the effects of absenteeism itself must be understood. Absenteeism can be defined as repeated chronic absence from school, resulting in missing at least 10% of the school year (Balfanz & Byrnes, 2012). Attendance in the classroom is vital for students to achieve test scores that meet benchmarks set by the state and school districts. Authors Aucejo and Romano found that reduced absences had a more profound impact on student exam achievement than increased instruction time. They found that students scored up to five percentage points higher on math and reading exams when they missed less instructional time (2016). Students who missed school in the days leading to the exam showed weaker performances on English Language Arts and Mathematics exams (Gottfried & Kirksey, 2017, p. 126). Chronically absent students would also be more likely to exhibit negative behavior toward their classmates, creating further disruptions to the learning environment and causing a loss of instructional time for their peers (Gottfried, 2019, p. 5).

## School Busing and Attendance

Michael A. Gottfried suggests that students who take the school bus have fewer absences overall than students who did not take the bus (2017, p. 587). Gottfried found that kindergartners who took the bus were more likely to attend school and not be chronically absent by three percentage points more than students who did not take the bus to school (2017, p. 581). Kindergarten children are as a population of interest for absenteeism because they typically experience

significant routine changes as they enter Kindergarten. Their parents or guardians must ensure their children make it to school on time every day (Gottfried, 2017, p. 574). Furthermore, their first year of school often has the highest percentage of absenteeism. With the help of busing, families can establish a routine that saves them time and money when they have strict work schedules and tight budgets (Gottfried, 2017, p. 574).

## School Transportation Costs

Students in middle school and high school also undergo a change of routine which could potentially increase their absenteeism as they switch to open-enrollment schools and begin to experience increased autonomy (Stein & Grigg, 2019, p. 1840). One argument for cutting back on school busing systems is cost. Research into school bus usage has shown that school districts have cut down on funding for busing due to budget constraints (Gottfried et al., 2021a). Although the solution may save school districts money in the short term, the money saved may not be more than the school districts could lose in funding due to increased absenteeism (Gottfried, 2017, p. 572).

## Urban Communities

Current literature about the use of public transportation and attending school has largely focused on urban school districts and communities (Stein & Grigg, 2019). Urban school districts are of interest because their enrollment policies families more agency in deciding where they learn (Stein & Grigg, 2019, p. 1846). Rural communities also may not have as robust an infrastructure as larger urban communities. As a result, transit systems and student routines could operate differently and yield different results on chronic absenteeism (Gottfried et al., 2021b).

Challenges to transit systems in larger communities include transferring between routes and the increase



in commute time, as students may spend more time waiting for their buses (Stein & Grigg, 2019, p. 1837). These findings are important to keep in mind as increased commute time or complexity led to additional absences in students by 13%, equivalent to an extra day and a half missed (Stein & Grigg, 2019, p. 1853). Another key finding in the article was how increased commute time contributed to student absenteeism. The authors found that every 10 minutes in commute time resulted in an extra one-third of a day missing. These extra missed days compound with the missed days those high schoolers already have, causing students to miss more of their instructional time in the classroom (Stein & Grigg, 2019, p. 1853).

## Open Enrollment and Transportation

Students in some larger districts have the opportunity to enroll in schools of their choice, regardless of the distance they live from the school. This can also benefit students who would otherwise be required to attend a school that is not performing as well. Open enrollment allows them to attend a school anywhere in the district to achieve the best possible educational outcome (Ledwith, 2010). Open enrollment schools allow students and their parents to attend schools they believe will be best for their educational needs, however, this may result in increased absences among students. Open enrollment policies require families and students to adapt to new commutes that may be longer and more complex than anticipated (Stein & Grigg, 2019, p. 1840). A potential solution identified by Stein & Grigg was to encourage the students and their families to ride public transportation to schools of interest. This would help them become better informed when it came time to enroll (2019, p. 1855).

## Rural Communities

Rural populations live in areas that have a different geographic setting than the density of large urban

cities. Current research has shown that rates of absenteeism are similar across urban and rural settings (Gottfried et al., 2021b). Research examining the connection between absenteeism in rural school districts and students who took the school bus revealed that kindergarten students had fewer absences than their peers who did not take the bus (Gottfried et al., 2021b). When comparing this data to prior studies with a similar population and research goal, school districts saw a bigger reduction in chronic absenteeism by two percentage points (Gottfried, 2017, p. 585).

## Free Public Busing

The first study concerning this topic was on a 2002 program benefitting low-income middle and high school students located in the San Francisco Bay Area (McDonald et al., 2006, p. 153). This study aimed to find the effect the bus passes had on student attendance and participation in after-school activities. No significant attendance changes were found (McDonald et al., 2006, p. 158). After-school program coordinators noted, however, that a key factor affecting bus ridership was bus stop safety (McDonald et al., 2006, p. 159). Munoz and Sandoval (2022) focused on the effects of a free public busing program on students' educational outcomes that began in 2016 in Tallahassee, Florida. They found that the program resulted in increased absences and an increase in chronic absenteeism. Students were found to attend less school by 1% after the program was initiated, and their chronic absenteeism increased by 2-4 percentage points (Munoz & Sandoval, 2022, p. 558). These rates were higher for high school students and minority students, especially if they attended a school that had a high percentage of students on free and reduced lunch programs. The authors noted the lack of literature on the topic and are the first to establish a causal link between student educational outcomes and fare-free bus programs (Munoz & Sandoval, 2022, p. 559).

## Conclusion

Fare-free busing programs are not a new phenomenon in the United States, yet the potential impacts of such programs have gone largely unstudied. Literature in the field of transportation and its effects on students, however, has concluded that access to transportation has resulted in increased attendance for students. To benefit from these results, school districts should make school busing more attractive to increase ridership and attendance to school.

## Future Research

Further research should consider the impact that awareness and familiarity with the public bus system have on student absences and chronic absenteeism. This insight could be used by school districts to minimize absences. Additionally, students could be surveyed to gain their perspective on the utilization of a fare-free busing program. One example of further research could be a case study in school districts where fare-free busing programs have been implemented.

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# Efficacy of Interventions that Address Intimate Partner Violence in the Higher Education Setting

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## Introduction

Intimate partner violence (IPV), as defined by the Centers for Disease Control and Prevention (CDC), is an act of stalking, physical or sexual violence, and psychological aggression that transpires during an intimate relationship. The intensity and frequency of IPV can vary. IPV can span from one incident of violence, which may potentially have an enduring impact, to chronic incidents over the course of several years (CDC, 2018; 2021). Previous literature has utilized diverse terms to interchangeably classify IPV, such as dating abuse/violence and domestic abuse/violence.

Domestic violence normally calls attention to married couples but can also refer to child or elder abuse inflicted by any member of the family (World, 2012). Alternatively, dating violence is usually used to define abuse among young adults in romantic relationships (CDC, 2018). To present a precise and persistent definition, the National Center for Injury Prevention and Control (NCIPC) along with the CDC characterizes IPV

as “abuse committed at the hands of a past or present dating partner, boyfriends/girlfriends, or reoccurring sexual partners and spouses, which may occur in cohabitating or non-cohabitating relationships” (Breiding et al., 2015). Therefore, the term intimate partner violence (IPV) is utilized throughout this study.

This study aims to contribute to the literature by exploring the academic consequences of IPV among college students. I will examine the different types of interventions and their efficacy for at-risk groups.

Peer-reviewed articles were collected and examined through the Wichita State University Database, as well as articles from medical entities including the Centers for Disease Control and National Center for Injury Prevention and Control. Finally, online websites and guides from preventative and targeted intervention programs were examined.

## Literature Review

Data from the National Intimate Partner and Sexual Violence Survey (NISVS) revealed that approximately 8.5 million women (7%) and 4 million men (4%) in the United States have reported encounters of stalking, physical violence, or even rape (Niolon et al., 2017). Additional data disclosed that roughly 47% of females and males in the United States have experienced psychological abuse during their lifespan from an intimate partner (Duval et al., 2020). The Youth Behavior Survey by the CDC shows 1 in 12 high school students are exposed to some form of physical violence.

However, few studies recognize how frequently IPV occurs on college campuses. Research has found that 10% to 50% of college students encounter some form of IPV (Dardis et al., 2017; Kaukinen, 2014; Spencer et al., 2021). Other researchers found that 21% of students in college have reported encounters of IPV executed by a current partner, and 32% reported encounters of IPV by a former partner (Brennan et al., 2021; Sinozich & Langton, 2014). Of those who report some form of IPV, approximately 10-15% of relationships in college include acts of physical violence, 15-25% include acts of sexual aggression, and 50-80% include psychological aggression (Kaukinen, 2014; Wood et al., 2020).

College students as a whole are at an increased risk of mental health concerns (Assari and Lankarani, 2018). For many stressors include academic pressure, increased workload, greater individual responsibility, and separation from social support (e.g., family).

Additionally, college students are building their emotional maturity and making adjustments within themselves (Banyard et al., 2020; Assari et al., 2018). For these reasons, college students are at a higher risk of intimate partner violence (Assari et al., 2018).

Preventative programs for IPV focus on curriculums for middle/high school students and their parents/guardians, and educators. Preventative programs educate individuals about what orchestrates and causes a healthy relationship and/or an abusive one. They focus on the consequences of dating violence, improve competence — including resources to help themselves or others involved in dating violence— and lastly, equip, empower, and elevate healthy relationships. This can include a curriculum about recognizing dating abuse/violence, communication techniques, and settling disagreements.

Targeted intervention programs focus on supporting adult victims of IPV. They enhance the safety of support, healing, and empowerment of survivors of victimization to not return to their abusive, unhealthy relationships. These programs focus on community-based case management and housing support. Additionally, targeted intervention programs center on legal services, protection orders, and education/training to equip and empower survivors of IPV.

## Discussion

IPV is a significant topic facing society today. Data from the National Intimate Partner and Sexual Violence Survey (NISVS) revealed that approximately 8.5 million women (7%) and 4 million men (4%) in the United States have reported encounters of stalking, physical violence, or even rape (Niolon et al., 2017). Roughly 47% of females and males in the United States have experienced psychological abuse during their lifespan from an intimate partner (Duval et al., 2020).

College students are at the highest risk of victimization for IPV. Consequences for college students that experience victimization are at higher risk for lower academic efficiency, institutional commitment, scholastic conscientiousness, and higher stress levels. (Assari and Lankarani, 2018). While the CDC states





that IPV is preventable, there are minimal studies to showcase the efficiency of intervention programs for college students.

However, many targeted interventions exist, such as Safe at Home, Love is Respect, and Connections for Abused Women and their Children (CAWC). While these targeted intervention programs have been analyzed for how they operate and the curriculum is utilized, there is little to no evidence of the efficiency of prevention. Additionally, there are limited studies for targeted intervention as it relates to college students.

Future studies should focus on the college student demographic and analyze the efficiency of targeted intervention programs. This analysis can be done by a pre-post survey to analyze the victim's progression and the efficiency of the program. Data could also be collected from a mandatory check-in with victims. While IPV can be detoured (CDC, 2021), targeted interventions are crucial for those that experience IPV.

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# Language Change and the Call for a More Gender-Inclusive French

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## Introduction

This study examines current efforts toward gender-inclusive language in French, focusing primarily on personal pronouns and adjective agreement. It examines the history of this movement, as well as the difficulties that a grammatically gendered language presents to this undertaking. This research also explores the larger debate surrounding the discussion on gender-neutral language and language change. The topic of gender inclusivity is rapidly growing within the field of linguistics. While feminists have long desired the introduction and popular use of gender-fair language, the trend toward gender-neutral language and away from the gender binary is a current cultural shift that demands the attention of scholars worldwide. The present research in the area is highly anglocentric, and there is little study of this in other languages. The need for gender-inclusive and gender-neutral language has been noted by feminists, activists, linguists, educators, and members of the LGBTQ+ community alike (Kosnick, 2019, p. 2).

This extended literature review employs a narrative approach to explore various studies and articles surrounding the accommodation of gender-inclusive language within French. A systematic search strategy drawing from various databases, including ProQuest, Google Scholar, and EBSCOHost databases, was utilized in the gathering of relevant literature. Specific keywords were applied to these databases, including "[French] gender-neutral pronouns," "[French] gender-inclusive language," "[French] language change," and "French iel." Web searches were also employed to locate specific statements from the Académie Française.

## Background

### Inclusive and Neutral Language

There is a growing call for the addition and regular use of gender-inclusive language from members of the LGBTQ+ community and feminist organizations alike. Gender-inclusive language is the intentional incorporation of language that can safely identify all gender identities (Flanigan, 2013, p. 29). The avoidance of androcentrism is crucial to women in these societies, as masculine generics are discriminatory and can pose a danger to women (Prewitt-Freilino et al., 2012, p. 270). Masculine generics are largely associated with masculine traits and stereotypes, which can lead to fewer women in jobs and fields that use male generics in their descriptions. Masculine generics have also been shown to influence court cases and whether or not a jury finds an individual guilty (Prewitt-Freilino et al., 2012, p. 271). These are examples of the impactful side effects of using masculine generics that can be prevented through the implementation of gender-neutral language.

Gender-neutral language also provides representation for non-binary identities and helps limit misgendering (Hord, 2016, p. 5). While women fight against patriarchal customs, non-binary individuals are often overlooked completely (Shroy, p. 10). The non-binary identity encompasses those who do not fall neatly within the gender binary, including those who do not have a gender, those who identify as neither, both, or somewhere between the binary (Kosnick, 2019, p. 13). It is important to note that while recognition of these identities may be newly garnered, archaeological evidence suggests that gender identities outside the binary might have existed in various cultures for thousands of years (Stockett, 2005, p. 570).

Gender-neutral pronouns can help non-binary and queer individuals express themselves and their gender (Hord, 2016, p. 1). These pronouns can also limit the

potential of misgendering non-binary individuals. Misgendering (mégenrer in French), most commonly heard in the transgender community, occurs when someone uses the incorrect pronoun for an individual, which can cause psychological harm (Hord, 2016, p. 5; Swamy, 2019, p. 6). It is important to note, however, that one does not need to identify as transgender and/or non-binary to use gender-neutral personal pronouns. Furthermore, some non-binary people personally prefer gendered pronouns or a combination of gender-marked and non-gendered pronouns (Kosnick, 2019, p. 13).

### Language Change

Some prescriptivists believe that “language change is equated with language decline,” hence their negativity toward the use of gender-neutral language (Hord, 2016, p. 8). However, change is a natural, continual occurrence in the history of a language. Change is gradual and happens at a pace slow enough for speakers to adapt alongside the language (McMahon, 1994, p. 6). How a language is used in everyday life influences what becomes of the language (Hord, 2016, p. 8). The purpose of language is communication, and speakers conform the language to fit their needs (McMahon, 1994, p. 6). However, language can also be artificially changed by influential, implementations of rules, such as some of those existing in French today.

## Towards an Inclusive French Gendered Languages

The case of language change is particularly interesting in French since there is a body that oversees the language and prescribes grammar onto it: l'Académie Française. In the 17th century, the rule of le masculin l'emporte sur le féminin was introduced, which states that if a group contains even one man, the group must be referred to in a masculine manner, with masculine



adjective agreement (Swamy, 2019, p. 4). Additionally, during the 17th century, feminine occupational terms were removed from dictionaries and erased from the language (Kosnick, 2019, p. 4). This language evolution was politically imposed to assert male superiority in France (Swamy, 2019, p. 5). Since “cultural beliefs and values influence the interpretation and reform of gendered language practices,” it is understandable that this societal shift toward greater recognition of non-binary identities would be reflected in language change to provide visibility and reference to these identities (Flanigan, 2013, p. 28). As demonstrated by the dramatic increase in the use of the ‘singular they’ in English, directed action can also greatly influence language change.

Grammatically gendered languages are significantly challenged in the creation and use of gender-inclusive language, and, in turn, their inadequacies and shortcomings have the potential to harm transgender individuals. Gender-affirming language, or language that affirms one’s gender, has been found to cause a feeling of respect and security in transgender individuals while misgendering through the use of incorrect pronouns can make transgender people feel unsafe and disrespected. Systematic misgendering and transphobia encourage the marginalization of the transgender community and can lead to violence and mental health issues (Sevelius, 2020, p. 2).

## Gendered-Inclusive Language Practices in French

While both English-speaking and French-speaking feminists have fought against the “derogation of women” within language, English-speaking feminists concentrated on the elimination of gendered occupational titles such as ‘actress’ and ‘waitress,’ while French feminists have long fought for the feminization of occupational titles (Hord, 2016, p. 12). This is seen as an attempt to eliminate the male bias in the generic

masculine of gendered languages. Anna Livia, the late feminist and queer linguist, explained the difference in goals as a result of the grammatical gender structures of each of the languages (Livia, 2001, p. 194). In addition, while feminist and transgender issues are not always recognized as two parts of the same whole, and some English-speaking feminists also protest transgender people and their rights, French feminists, in general, have focused considerably less on intersectionality concerning transgender issues than their Anglophone counterparts (Baril, 2017, p. 126).

In the effort to achieve gender inclusivity in French, strategies such as neologisms, circumlocution, and punctuation suffixation have been employed, each with its own strengths and weaknesses. Neologisms, particularly the neopronoun *iel*, introduce gender-neutral options and articulate the trans experience, while circumlocution helps soften opposition to language change by maintaining traditional structures. Punctuation suffixation recognizes both masculine and feminine forms but falls short of achieving true gender neutrality. These practices are evolving, but there is still a need for better options to fully address the needs of the non-binary community in the French language (Kosnick, 2019, p. 6; Knisely, 2020a, p. 866).

## Perspectives and Opinions

Language change to increase inclusivity will and is occurring gradually.

Between the lack of coverage in the French media and the strong disapproval from the Académie, conservative, prescriptivist ideals are impeding the cultural shift occurring worldwide, causing the French language to fall behind others in gender equality and in adequacy for non-binary speakers. France, by having strong government opposition to gender-inclusive writing, creates a strong contrast between the country and others in Europe and North America

that act more welcoming, linguistically, to all genders (Burnett & Pozniak, 2021, p. 811).

## Discussion & Further Study

Societal shifts demand language change, and French must adapt to this need. Otherwise, the current language constraints will continue to cause harm to many individuals. It is critical that French organizations and institutions put more effort into gender-inclusive language and campaigns, beginning with l'Académie Française. Public perception is likely to shift following official acceptance. This will tremendously help marginalized communities and work as harm reduction.

Future research on this subject could examine perceptions of French speakers on gender-inclusive gender-neutral language. Trends among the various demographics could then be studied, which might be useful for activists in strategizing techniques to alter perceptions or gain awareness. Another focus could be pedagogical attempts to integrate gender-inclusive language and writing into the language classroom. In addition to these ideas, one could conduct a close comparison of other grammatically gendered languages, such as Spanish, to French, to see how to implement tactics of non-binary individuals in those languages. Studying the difference in how French non-binary individuals identify themselves and use gender-neutral language in public versus in LGBTQ+ spaces could highlight important differences and safety issues.

Efforts toward making language more gender-inclusive and neutral are gaining momentum in the English-speaking world but are still needing improvement in the Francophone one. The goals of feminization and degenderization began with feminists in the 1970s and are shifting from a focus on visibility for women to visibility for all genders, including non-binary ones. Despite the challenges presented against gender-

neutral language to French speakers, several strategies are emerging to combat gendered language and bring representation to non-binary identities, such as neologisms, circumlocution, and punctuation suffixation. These are not widely known or accepted and have been disapproved of in an official, public manner by the Académie Française.

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